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REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION, FISCAL YEAR 1984

HEARING

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

FIRST SESSION

ON

PROPOSED AUTHORIZATIONS FOR THE NATIONAL SCIENCE FOUNDATION FOR FISCAL YEAR 1984

MARCH 18, 1983

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REAUTHORIZATION OF THE NATIONAL SCIENCE FOUNDATION, FISCAL YEAR 1984

FRIDAY, MARCH 18, 1983

U.S. SENATE,
COMMITTEE ON LABOR AND HUMAN RESOURCES,
Washington, D.C.

The committee met, pursuant to notice, at 9:39 a.m., in room SD-430, Dirksen Senate Office Building, Senator Orrin Hatch (chairman of the committee) presiding.

Present: Senators Hatch, Stafford, and Pell.

OPENING STATEMENT OF SENATOR HATCH

The CHAIRMAN. I would like to welcome everyone to the hearing this morning on the President's proposal to reauthorize the research and related activities of the National Science Foundation for fiscal year 1984.

I believe all of us seek to establish the United States as the preeminent power in scientific know-how throughout the world. While American leadership in this area has never dipped below No. 1, it has slipped to the point at which we can no longer take it for granted. I share the commitment of the Reagan administration to devote the resources necessary to rebuilt our position in science and technology. While I do not believe that science is the only answer to all our economic problems, I do believe strongly that we cannot recover either our domestic or international economic position without an increase in productivity spurred by new production techniques, new products, and new systems.

While our Nation requires these new technologies, we cannot obtain them overnight. The development process takes a very long time in most cases and begins with basic scientific inquiry. New knowledge about natural laws is a necessary prelude to applied research and innovation geared to address national problems and improve our quality of life.

We will hear this morning about important research that provided pivotal information paving the way for development of the artificial heart. If we ever had doubts about the significance of NSF-supported basic research, this success story should erase them and solidify our efforts as a nation to maintain the high quality of research now underway in our colleges and universities.

The purpose of this morning's hearing is to examine the administration's proposed budget for NSF for fiscal year 1984. We will restrict our commentary to the research component of NSF. I do not want to shortchange the science and engineering education direc-

torate this year, particularly since the committee has a number of science education proposals pending. Senator Stafford, chairman of the Education, Arts and Humanities Subcommittee, and Senator Pell, who is with us today, his ranking minority member, have been holding hearings on science education programs as they pertain to the Department of Education. I will hold another full committee hearing on April 18 to discuss science education issues involving the National Science Foundation.

It is our intention for the Labor and Human Resources Committee to produce comprehensive legislation during this session of Congress to deal with the pressing national matter of science and mathematics education in our elementary and secondary schools. In view of this, I would like to request that we focus as much as possible on the research and related activities functions of the National Science Foundation.

The Reagan administration has proposed a 17.8-percent increase in funding for NSF. Our purpose is to evaluate the specific level of funding for each directorate, keeping in mind our overall program goals and priorities, including the need for accountability and effective administration.

On behalf of the committee, I want to express appreciation to all of our witnesses who are giving their own time to be present today. We could not understand these issues as well without your help and the testimony you are about to give us here today.

I am happy to have you here. I am also very happy to have Senator Pell, who plays a very active role on this committee and is a dear friend, here today to participate in these hearings.

Senator Pell, do you have any opening comments?

Senator PELL. Thank you very much, Mr. Chairman.

I want to congratulate you on holding this day of hearings and another one, as I understand it, on April 18 on this subject, which is such an important subject.

I think the President was very right when he mentioned the need for math and science in his state of the Union speech. All of us working on this problem, we hope we will converge on a pretty good bill, which under Senator Hatch's chairmanship this committee will put forward. I would hope you would put into it the Education and Economic Security Act, a bill which is also before this committee, and various other measures. Eventually what will come out of this, I hope, is a wonderfully strong bill that will have bipartisan support and will sweep through the Congress.

Again, congratulations to the chairman for his leadership.

The CHAIRMAN. Thank you, Senator Pell.

We will now receive for the record prepared statements by Senators Kennedy and Dodd.

[The statements referred to follow:]

PREPARED STATEMENT OF SENATOR KENNEDY

Senator KENNEDY. For over thirty years, The National Science Foundation has stimulated America scientific research and technological achievement. It has been the crucial partner in both expanding science education and supporting science research.

The National Science Fouocation is one of our country's primary supporters for basic and applied research; it encourages young people to enter scientific and technical fields; it keeps scientists aware of the constantly changing body of knowledge

in their fields, and it offers the general public an understanding of the issues of ethics and values that arise in science and engineering.

This Nation faces great challenges in its struggle to regain economic strength and security; a vigorous and creative scientific community is essential to meet these challenges. We can on longer afford to allow our national investment in research and development to decline if we are to meet the challenge of the competition in the international economy.

Therefore, I am pleased that the administration proposes to increase the fiscal year 1984 NSF budget by $195 million—17.8 percent over fiscal year 1983.

This proposed increase will mean more research grants, more graduate students, and more graduate fellowships, I am particularly pleased that the fiscal year 1984 budget contains a 60.5 percent-increase for R&D equipment and instrumentation. This increase is sorely needed by scientists and universities to replace aging equipment and deteriorating instruments.

While there is good news in the President's budget, there is also bad news. I am extremely disappointed that the administration budget provides no increase for the women and minorities in science programs. These programs would be level funded at 5.5 million. In fact, this budget is really a cut. Since CBO estimates that increased costs will eat up almost 5 percent of thes funds.

Almost 2½ years ago, the Congress sought to deal with the significant underrepresentation of women and minorities in science and engineering through the science and technology Equal Opportunities Act. Unfortunately, the intent of this legislation has been frustrated since then and today, we witness a further erosion in the efforts to achieve the objectives of this landmark initiative. Less than 1 percent of NSF's budget is earmarked for these programs.

None of the almost $200 million increase proposed for NSF will go to advancement of women and minorities in science and engineering.

We cannot turn our back on the struggles of those who have been denied access to these critical fields. We cannot afford to leave anyone behind.

Finally, the administration proposes that the NSF spend just $39 million for science education in fiscal year 1984—$19 million for graduate fellowships and only $20 million for teacher improvement.

The President does not seem to realize that we have a crisis on our hands. The President has apparently not read the volumes of accounts in newspapers, magazines, trade journals, congressional testimony, and letters from concerned citizens.

Mr. Chairman, not since the launching of Sputnik has there been a greater need to revitalize our science education programs. We do not need a token gesture. We do need a bold and comprehensive initiative to respond to the concerns of our citizens about our failing performance in science education.

A number of my colleagues have introduced measures to deal with this crisis and next week, I will introduce the National Education for Economic Development [NEED] Act. My bill is directed to States and local school districts, universities and colleges, business and industry, and the Federal Government. This comprehensive partnership will reach out to teachers, to students, to women and minorities, to the economically disadvantaged, and to the handicapped to put the benefit of modern science, mathematics, and engineering education within their reach.

Mr. Chairman, there is no greater or more exciting challenge facing us than making our Nation second to none in science and engineering. I look forward to working with you on these vital issues.

Prepared Statement of Senator Dodd

Senator Dodd. Progress in scientific knowledge does not recognize political boundaries. For that reason, international cooperative scientific activities provide support for programs in which U.S. scientists interact with foreign scientists in specifically designed programs. These programs demand joint planning and funding for research projects, seminars and visits to scientific institutions and organizations.

International science has played an important role in fostering peaceful interactions between the U.S. and other nations. Some of the best minds in the world have engagd in combined efforts to seek solutions to problems of shared interest through the application of science and technology.

Some examples of programs which have been supported under cooperative scientific activities are: cooperative research and development with the U.S.S.R. in high quality steel and alloys for construction of more reliable bridges; joint projects with Latin American countries to study, understand, and predict the effects of migration upon employment, enonomic growth, and society; joint ventures with Japan for the

study of improved building practices and codes and for planning public disaster and recovery programs in the aftermath of earthquakes; and U.S.-China joint metallurgy symposiums (which were of particular interest to archeologists and researchers in the history of technology) gave U.S. scientists access for the first time to artifacts available only in China.

Such programs are of great importance to scientific and political communities. These joint ventures are by virtue of their cooperative nature, able to overcome barriers of language, culture, and political differences.

International scientific programs may be compared appropriately to the successful efforts of the Peace Corps—people working together in the absence of intimidation or suspicion; people sharing knowledge, skills and experiences without the speculative intent of ulterior motives; simply put, people working together for the benefit of people.

The CHAIRMAN. At this time, then, we will call the National Science Foundation witnesses: Dr. Edward A. Knapp, the Director of the National Science Foundation, and Dr. Lewis M. Branscomb, the Chairman of the National Science Board.

We are delighted to have both of you with us here today. We are looking forward to working with you. We are impressed with what you have already started and are trying to do. We hope to be a source of aid and support in the coming months and years.

STATEMENT OF DR. EDWARD A. KNAPP, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. KNAPP. Thank you, Mr. Chairman. I would like to submit for the record my full testimony and summarize it briefly.

The CHAIRMAN. We appreciate that. Without objection, the full testimony will be placed in the record as though fully delivered following your oral presentation.

Dr. KNAPP. Mr. Chairman and members of the committee, this is my first appearance before you. It is a pleasure for me to be here to discuss the administration's proposed budget for the National Science Foundation for fiscal year 1984.

I am accompanied today by Dr. Lewis M. Branscomb, Chairman of the National Science Board. He will describe the Board's role in developing NSF's program priorities and some recent Foundation activities.

I know that this committee has a particular interest in Foundation activities which support science and engineering education. I share this interest and am pleased that I will have the opportunity to discuss them during my next appearance before you on the fiscal year 1984 budget request. They deserve NSF's complete attention.

Today I would like to concentrate on the NSF research activities and convey to you the plans and priorities for these science and engineering programs which constitute more than 95 percent of NSF's budget request.

In a recent speech to the Massachusetts High Tech Council Forum, the President underscored the Federal Government's policy toward research:

> We will propose unprecedented increases in fundamental research, because it offers essential support for our industries and our defense needs. And we will channel this research into the most promising areas—those most likely to extend the benefits of American science expertise to industry. As you know, research is the wellspring of ideas that leads to new technologies, such as the transistor and the laser. And it is, also, the key source for the highly trained scientists and engineers that . . . we will need to lead us into the next century.

The fundamental research supported by NSF makes a central and creative contribution to the economic health and vitality of this Nation. Without a strong, long-term research effort, the innovation of the high-tech economy would fade quickly.

The reliance on academic institutions for the performance of a major part of basic research in this country is a distinctive strength of the scientific enterprise. It insures a link between the training of future scientists and engineers and the conduct of leading-edge research important to continued U.S. scientific and technological leadership and economic competitiveness. This link makes possible a continuous flow of young engineers and scientists with new ideas and technical sophistication into the industries, colleges, universities, and governmental laboratories. Indeed, it is not an exaggeration to say that most of the Foundation's budget supports science and engineering education.

The fiscal year 1984 budget request for the Foundation is approximately $1.3 billion, an increase of 17.8 percent more than fiscal year 1983. It features an 18.3-percent increase in the support of basic research and includes a Presidential initiative to encourage our most outstanding young scientists and engineers to pursue academic careers through a cooperative Government/private sector research awards program. It will increase support of research instrumentation in most of the Foundation's activities by 61 percent more than fiscal year 1983. Support of graduate students and postdoctorate researchers will be enhanced in several areas. And, finally, the budget request embodies a new management philosophy and practice for the Foundation. Special programs designed for selected groups and institutions will become integral parts of NSF's research activities.

In formulating the program and budget priorities for fiscal year 1984, several criteria were used. These included scientific excellence and promise of the activity; need to sustain scientific momentum in certain key areas; maintenance of a broad base of support across a wide variety of science and engineering disciplines; and potential of an activity to contribute to national economic and productivity goals.

The requested rate of growth in the Foundation's budget over previous fiscal years and the emphases contained in this budget reflect three things:

First, the importance of basic research in laying the groundwork for long-term economic growth and providing a foundation for the technologies on which national security and other goals depend.

Second, the need to revitalize the research base in the colleges and universities and to insure their continuing ability to produce world class scientists and engineers in the years ahead.

Third, the importance of quality education in science and mathematics in the secondary schools to the continuance of U.S. technological and economic leadership in the world.

Let me turn now to several programs that in previous years have been treated as "set asides." The Foundation has a number of these programs that cut across the concerns of all disciplines and bear on the overall health and vitality of science. These programs address such activities as research at undergraduate institutions,

international cooperative research, and expanded participation of women and minorities in scientific careers.

Beginning in fiscal year 1984, research program officers will be required to adopt a broader view of their responsibilities toward the health of science. NSF's budget request anticipates that these set-aside programs will be integrated, budgetarily and managerially, into the mainstream of the Foundation's research activities.

I believe the integration of these activities into the mainline research programs in fiscal year 1984 will enhance—greatly and more permanently—NSF's support of women, minority, undergraduate faculty research, and international activities in the Foundation. It also will further the goal of broadening the Foundation's attention to the health of science and technology in the United States.

Turning the three decades of the Foundation's existence, its budgets have had strong bipartisan and public support. I believe NSF has proposed a strong, well-conceived budget that once again is worthy of your approval. For my part, I will work with the National Science Board, with Foundation staff, and with the research community to see that support of excellence through competition continues to be the goal of all the Foundation's programs. Thank you.

[The prepared statement of Dr. Knapp follows:]

STATEMENT OF

DR. EDWARD A. KNAPP
DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE
COMMITTEE ON LABOR AND HUMAN RESOURCES
UNITED STATES SENATE
MARCH 18, 1983

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE:

THIS IS MY FIRST APPEARANCE BEFORE YOU AND IT IS A PLEASURE FOR ME TO BE HERE TO BEGIN OUR DISCUSSION OF THE ADMINISTRATION'S PROPOSED BUDGET FOR THE NATIONAL SCIENCE FOUNDATION FOR FY 1984. I AM ACCOMPANIED TODAY BY DR. LEWIS M. BRANSCOMB, CHAIRMAN OF THE NATIONAL SCIENCE BOARD, WHO WILL BE DESCRIBING THE ROLE OF THE BOARD IN DEVELOPING OUR PROGRAM PRIORITIES AS WELL AS SOME OF ITS OTHER RECENT ACTIVITIES.

I KNOW THAT THIS COMMITTEE HAS A PARTICULAR INTEREST IN THOSE FOUNDATION ACTIVITIES WHICH SUPPORT SCIENCE AND ENGINEERING EDUCATION. I SHARE THIS INTEREST AND AM PLEASED THAT I WILL HAVE THE OPPORTUNITY TO FOCUS ON THEM DURING MY NEXT APPEARANCE BEFORE YOU ON THE FY 1984 BUDGET REQUEST. THEY ARE DESERVING OF OUR COMPLETE ATTENTION. TODAY,

I WOULD LIKE TO CONCENTRATE ON THE NSF RESEARCH ACTIVITIES AND CONVEY TO YOU OUR PLANS AND PRIORITIES FOR THESE IMPORTANT SCIENCE AND ENGINEERING PROGRAMS WHICH CONSTITUTE OVER 95 PERCENT OF OUR BUDGET REQUEST.

The Value of Research to the Nation

I THINK IT'S TIMELY FOR US TO CONSIDER, FOR A MOMENT, THE CONTRIBUTION OF BASIC RESEARCH TO OUR SOCIETY AND HOW SCIENCE PLAYS AN IMPORTANT PART IN ADDRESSING MANY OF THE CURRENT AND LONG-TERM CONCERNS OF THE NATION. REGARDLESS OF OUR PROFESSION OR WALK OF LIFE, WE ALL HAVE AN ONGOING STAKE IN KEEPING NEW SCIENTIFIC IDEAS FLOWING FROM RESEARCH. WE HEAR A LOT THESE DAYS ABOUT THE NEED TO PRESERVE AMERICA'S INDUSTRIAL COMPETITIVENESS AND TO PROVIDE THE PERSONNEL TO CARRY THIS COUNTRY INTO A NEW TECHNOLOGICAL AGE.

IN A RECENT SPEECH TO THE MASSACHUSETTS HIGH TECH COUNCIL FORUM, THE PRESIDENT UNDERSCORED THE GOVERNMENT'S POLICY TOWARD RESEARCH:

> "WE WILL PROPOSE UNPRECEDENTED INCREASES IN FUNDAMENTAL RESEARCH, BECAUSE IT OFFERS ESSENTIAL SUPPORT FOR OUR INDUSTRIES AND OUR DEFENSE NEEDS. AND WE WILL CHANNEL THIS RESEARCH INTO THE MOST PROMISING AREAS--THOSE MOST LIKEY TO EXTEND THE BENEFITS OF AMERICAN SCIENCE EXPERTISE TO INDUSTRY. AS YOU KNOW, RESEARCH IS THE WELLSPRING OF IDEAS THAT LEADS TO NEW TECHNOLOGIES, SUCH AS THE TRANSISTOR AND

THE LASER. AND IT IS, ALSO, THE KEY SOURCE FOR THE HIGHLY TRAINED SCIENTISTS AND ENGINEERS THAT...WE WILL NEED TO LEAD US INTO THE NEXT CENTURY."

THE TYPE OF FUNDAMENTAL RESEARCH NSF SUPPORTS MAKES A CENTRAL AND CREATIVE CONTRIBUTION TO THE ECONOMIC HEALTH AND VITALITY OF THIS NATION. WITHOUT A STRONG LONG-TERM RESEARCH EFFORT, THE VITALITY AND INNOVATIVENESS SHOWN BY OUR HIGH-TECH ECONOMY WOULD QUICKLY FADE.

THE ROLE OF THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF RESEARCH

THE FOUNDATION OCCUPIES A UNIQUE PLACE IN THE RESEARCH COMMUNITY AND AMONG FEDERAL AGENCIES THAT SPONSOR RESEARCH. FIRST, THE STAFF OF THE FOUNDATION DOES NOT CONDUCT RESEARCH, THOUGH ITS PROGRAM OFFICERS ARE VIRTUALLY ALL SCIENTISTS OR ENGINEERS WITH ADVANCED DEGREES AND RESEARCH EXPERIENCE IN THE FIELDS FOR WHICH THEY ARE RESPONSIBLE. OUR FUNDS, IN THE FORM OF GRANTS AND CONTRACTS, SUPPORT SCIENTISTS AND ENGINEERS OUTSIDE THE GOVERNMENT, MOST FREQUENTLY IN UNIVERSITIES AND COLLEGES.

SECOND, THE CREATIVE IDEAS ON WHICH RESEARCH IS CONDUCTED COME FROM THE SCIENTISTS AND ENGINEERS THEMSELVES IN THE FORM OF UNSOLICITED RESEARCH PROPOSALS. EACH YEAR, THE FOUNDATION RECEIVES OVER 27,000 PROPOSALS. WITH THE ASSISTANCE OF CLOSE TO 50,000 SCIENTISTS, ENGINEERS, AND EDUCATORS SERVING AS ADVISORS AND PEER REVIEWERS, WE SELECT AND SUPPORT ABOUT 10,000 OF THESE PROPOSALS.

NSF AWARDS PROVIDE SUPPORT FOR THE TOOLS AND RESEARCH FACILITIES THAT PERMIT SCIENTIFIC ADVANCEMENT IN MANY DISCIPLINES. THIS SUPPORT RANGES FROM PURCHASES OF EQUIPMENT IN INDIVIDUAL RESEARCH PROJECTS TO THE SUPPORT OF MAJOR USER FACILITIES IN PHYSICS AND MATERIALS RESEARCH, THE ACADEMIC RESEARCH FLEET IN OCEANOGRAPHIC RESEARCH, FIVE NATIONAL ASTRONOMY CENTERS, AND A NATIONAL ATMOSPHERIC RESEARCH CENTER. IN ADDITION, THE FOUNDATION FUNDS AND MANAGES THE U.S. ANTARCTIC PROGRAM, THE PRINCIPAL EXPRESSION OF ACTIVE U.S. INTEREST IN THAT CONTINENT UNDER THE ANTARCTIC TREATY.

THOSE WHO SERVE AS PEER REVIEWERS AND ADVISORS DONATE THEIR TIME TO THE FOUNDATION BECAUSE THEY BELIEVE IT IS IMPORTANT WORK. THIS IS A KEY TO OUR ABILITY TO CONDUCT BUSINESS WITH AN OVERHEAD OF LESS THAN 6 PERCENT OF OUR TOTAL FUNDING. I BELIEVE THAT THE COMPETITIVE NATURE OF THE FOUNDATION'S AWARD PROCESS IS THE CORNERSTONE OF OUR ABILITY TO SUPPORT THE MOST PROMISING WORK FROM RESEARCHERS ACROSS THE NATION.

THIRD, THE FOUNDATION'S PROGRAMS ARE ESPECIALLY IMPORTANT FOR OUR COLLEGES AND UNIVERSITIES. IN RECENT YEARS, MORE THAN 25 PERCENT OF THE FEDERAL SUPPORT FOR BASIC RESEARCH AT ACADEMIC INSTITUTIONS HAS BEEN PROVIDED BY NSF. IN SOME FIELDS OF SCIENCE, SUCH AS MATHEMATICS, GROUNDBASED ASTRONOMY, ANTHROPOLOGY, AND GEOLOGY, AS MUCH AS 90 PERCENT OF BASIC ACADEMIC RESEARCH IS SUPPORTED BY THE FOUNDATION. ONE-THIRD OF THE FUNDAMENTAL WORK IN UNIVERSITIES AND COLLEGES IN ENGINEERING IS PROVIDED BY NSF.

THE RELIANCE ON ACADEMIC INSTITUTIONS FOR THE PERFORMANCE OF A MAJOR PART OF THE NATION'S BASIC RESEARCH IS A DISTINCTIVE STRENGTH OF OUR SCIENTIFIC ENTERPRISE. IT ENSURES A LINK BETWEEN THE TRAINING OF FUTURE SCIENTISTS AND ENGINEERS AND THE CONDUCT OF LEADING-EDGE RESEARCH IMPORTANT TO CONTINUED U.S. SCIENTIFIC AND TECHNOLOGICAL LEADERSHIP AND ECONOMIC COMPETITIVENESS. THIS LINK MAKES POSSIBLE A CONTINUOUS FLOW OF YOUNG ENGINEERS AND SCIENTISTS WITH NEW IDEAS AND TECHNICAL SOPHISTICATION INTO THIS NATION'S INDUSTRIES, COLLEGES AND UNIVERSITIES AND GOVERNMENTAL LABORATORIES. THUS, THE FOUNDATION'S BUDGET FOR RESEARCH SUPPORTS A SIGNIFICANT AMOUNT OF GRADUATE EDUCATION IN OUR LEADING ACADEMIC INSTITUTIONS AND INFLUENCES THE QUALITY AND THE SCIENTIFIC INTERESTS AND ABILITIES OF THOSE WHO REPRESENT THE TECHNOLOGICAL FUTURE OF THE U.S. INDEED, IT IS NOT AN EXAGGERATION TO SAY THAT MOST OF THE FOUNDATION'S BUDGET SUPPORTS SCIENCE AND ENGINEERING EDUCATION.

FINALLY, THE FOUNDATION HAS SUPPORTED AND CONTINUES TO SUPPORT SOME SMALL BUT CRITICALLY INNOVATIVE RESEARCH PROGRAMS WHICH PROVIDE A BRIDGE BETWEEN R&D IN INDUSTRY AND ACADEMIC BASIC RESEARCH. NSF'S SMALL BUSINESS INNOVATION RESEARCH PROGRAM, INITIATED IN FY 1977, SERVED AS THE PROTOTYPE FOR THE PROGRAM ENACTED BY THE CONGRESS IN THE SMALL BUSINESS INNOVATION DEVELOPMENT ACT OF FY 1982. AS IN OTHER FOUNDATION PROGRAMS, FUNDS ARE AWARDED ON A PEER REVIEWED, COMPETITIVE BASIS; A FIRST PHASE FOR THE STUDY OF THE FEASIBILITY OF AN IDEA. AFTER FURTHER REVIEW, THE MOST PROMISING PROJECTS ARE PROVIDED SECOND PHASE FUNDING. THE FINAL DEVELOPMENT INTO COMMERCIAL FORM IS CARRIED OUT SOLELY WITH PRIVATE VENTURE CAPITAL.

The NSF Budget Request

The 1984 budget request for the NSF is approximately $1.3 billion, an overall increase of 17.8 percent above Fiscal Year 1983, and features an 18.3 percent increase in the support of basic research. It encompasses a Presidential initiative to encourage our most outstanding young scientists and engineers to pursue academic careers through a cooperative government/private sector research awards program. It will increase support of research instrumentation in most of the Foundation's activities by 61 percent over 1983. Support of graduate students and post-doctorates will be enhanced in a number of areas. And, finally, it embodies a new management philosophy and practice for the Foundation. Special programs targeted at selected groups and institutions will become an integral part of the mainstream of NSF's research activities.

In formulating our program and budget priorities for FY 1984, several important criteria were used. These included: the scientific excellence and promise of the activity; the need to sustain scientific momentum in certain key areas; maintenance of a broad base of support across a wide variety of science and engineering disciplines; and the potential for an activity to contribute to important national economic and productivity goals.

THE REQUESTED RATE OF GROWTH IN THE FOUNDATION'S BUDGET OVER PREVIOUS FISCAL YEARS, AND THE EMPHASES CONTAINED IN THIS BUDGET, REFLECT THREE THINGS. FIRST, THE IMPORTANCE OF BASIC RESEARCH IN LAYING THE GROUNDWORK FOR LONG-TERM ECONOMIC GROWTH, AND PROVIDING A FOUNDATION FOR THE TECHNOLOGIES ON WHICH OUR NATIONAL SECURITY AND OTHER GOALS DEPEND. SECOND, THE NEED TO REVITALIZE OUR RESEARCH BASE IN THE NATION'S COLLEGES AND UNIVERSITIES AND TO ENSURE THEIR CONTINUING ABILITY TO PRODUCE "WORLD CLASS" SCIENTISTS AND ENGINEERS IN THE YEARS AHEAD. AND THIRD, THE IMPORTANCE OF QUALITY EDUCATION IN SCIENCE AND MATHEMATICS IN OUR SECONDARY SCHOOLS FOR CONTINUING U.S. TECHNOLOGICAL AND ECONOMIC LEADERSHIP IN THE WORLD.

EMPHASES IN RESEARCH PROGRAMS

THE FOUNDATION'S BUDGET REQUEST FOR THE MATHEMATICAL AND PHYSICAL SCIENCES, WHICH ACCOUNTS FOR CLOSE TO ONE-THIRD OF OUR RESEARCH ACTIVITIES, PLACES EMPHASIS ON THE MATHEMATICAL SCIENCES AND ON MATERIALS RESEARCH. SUPPORT WILL CONTINUE FOR MATHEMATICS RESEARCH INSTITUTES THAT PROVIDE GREATER INTERACTION AMONG MATHEMATICIANS. OUR EMPHASIS IN MATERIALS RESEARCH PERMITS A SUBSTANTIAL STRENGTHENING OF FACILITIES AND INSTRUMENTATION WITHIN THIS FIELD. MATERIALS SCIENCE IS AN AREA OF RESEARCH IN WHICH THE UNITED STATES NOW HOLDS A DECISIVE WORLD LEAD AND ONE WITH A POTENTIAL FOR SIGNIFICANT ADVANCES IN THE NEXT DECADE.

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In engineering, we will support work that underlies critical technologies and processes in our nation's computer, electronics, and chemical industries. Our program stresses such areas as robotics, micro-electronics, biotechnology, and automated manufacturing--key areas that can contribute to productivity and economic growth. In addition, we are responding to the current shortages in engineering faculty and advanced graduate students by proposing major increases in our support for young engineering faculty.

Primary emphasis in the biological sciences is placed on enhancing research in plant biology. Within the last few months, a remarkable breakthrough has been reported in the area of nitrogen fixation. Nitrogen is a paradox: it is an essential plant nutrient and plentiful, but inert and unavailable to most plants. It would be unavailable to all plants except for a group of bacteria that can convert nitrogen to ammonia which plants are capable of adsorbing.

This process, termed nitrogen fixation, is controlled by a set of genes in the bacteria. Recently, these bacterial genes were inserted into alfalfa cells and made to function there. The result was the visible formation of nodules, the tiny vesicles within which nitrogen fixation occurs, so the alfalfa cells could use the nitrogen. Since these genes presumably can be inserted in other plants, this advance signals a new frontier for plant biology and an expansion of the world's future food supply.

SUPPORT FOR THE SOCIAL AND ECONOMIC SCIENCES IS SUBSTANTIALLY INCREASED ABOVE FY 1983, ESPECIALLY IN THOSE AREAS--ECONOMICS AND DECISION AND MANAGEMENT SCIENCE--WITH SIGNIFICANT POTENTIAL FOR CONTRIBUTING TO ACHIEVEMENT OF OUR LONG-TERM ECONOMIC GOALS AND IMPROVING UNDERSTANDING OF THE IMPACT OF PUBLIC POLICIES ON THESE GOALS. SINCE 1968, FOR EXAMPLE, THE PANEL STUDY OF FAMILY INCOME DYNAMICS HAS KEPT TRACK OF THE ECONOMIC STATUS OF A REPRESENTATIVE SAMPLE OF 6,000 AMERICAN FAMILIES, INCLUDING FAMILIES ESTABLISHED BY CHILDREN LEAVING THE HOUSEHOLD. MEMBERS OF THE PANEL ARE INTERVIEWED ANNUALLY ON A BROAD RANGE OF TOPICS RELATED TO LIVING CONDITIONS WITHIN THE HOUSEHOLD AND WORK PATTERNS OUTSIDE. THE ENSUING ANALYSES HAVE PRODUCED NEW KNOWLEDGE ABOUT TRENDS IN INCOME AND THE WAY FAMILIES COPE WITH UNEMPLOYMENT, ILLNESS, INTERPERSONAL CONFLICT, AND OTHER FACTORS DIRECTLY OR INDIRECTLY AFFECTING ECONOMIC WELL-BEING.

LET ME TURN TO ANOTHER SCIENTIFIC AREA. ASTRONOMY IS AN OBSERVATIONAL RATHER THAN A LABORATORY SCIENCE--THE PHENOMENA OBSERVED ARE ON A COSMIC SCALE, AND THERE IS A NEED FOR LARGE AND EXPENSIVE INSTRUMENTS AND NATIONAL FACILITIES. IN FY 1984, WE WILL SUPPORT DESIGN STUDIES FOR THE VERY LONG BASELINE ARRAY, AN INSTRUMENT COMPRISING TEN RADIO TELESCOPES PLACED THROUGHOUT THE UNITED STATES. THE STUDIES BEING FUNDED WILL PROVIDE US WITH THE INFORMATION NECESSARY TO CONSIDER RECOMMENDING CONSTRUCTION OF THE VLBA IN FUTURE BUDGETS. IF CONSTRUCTED, THIS FACILITY WOULD BE THE LARGEST AND MOST POWERFUL INSTRUMENT OF ITS KIND IN THE WORLD. WITH ITS EXTRAORDINARILY HIGH RESOLUTION, WHICH IS 1000 TIMES THE BEST OPTICAL TELESCOPE, WE WILL BE ABLE TO "SEE" THE CENTERS OF DISTANT, GIANT

GALAXIES AND QUASARS. BECAUSE THESE STUDIES GO HAND IN HAND WITH SO MUCH STATE-OF-THE-ART TECHNOLOGY, MODERN ASTRONOMY ADDS SIGNIFICANTLY TO THE NATION'S POOL OF SCIENTIFICALLY AND TECHNICALLY-TRAINED MANPOWER. EVEN MORE THAN THAT, IT EXPANDS OUR UNDERSTANDING OF OUR UNIVERSE AND, THEREFORE, THE HUMAN IMAGINATION. PERHAPS THAT IS WHY ASTRONOMY IS THE OLDEST OF THE SCIENCES AND WHY THERE IS TODAY SUCH A LARGE POPULAR INTEREST IN IT. FEW OTHER SCIENCES CAN QUESTION SO DIRECTLY THE PAST, PRESENT, AND FUTURE OF THE UNIVERSE.

MANY OF YOU ARE FAMILIAR WITH OUR DEEP SEA DRILLING PROGRAM THAT HAS CONTRIBUTED SO MUCH TO THE UNDERSTANDING OF THE MOTIONS OF THE EARTH'S CRUST, AND THE MUCH-DISCUSSED QUESTION AS TO WHETHER TO REPLACE THE EXISTING DRILL SHIP, THE GLOMAR CHALLENGER, WITH ANOTHER, THE GLOMAR EXPLORER. NOT LONG AFTER I BECAME DIRECTOR I DECIDED THAT A NEW LOOK AT THIS ISSUE WAS IN ORDER. TO DO SO, NSF ESTABLISHED A SPECIAL ADVISORY COMMITTEE COMPOSED OF EARTH SCIENTISTS AND OCEAN SCIENTISTS TO RECOMMEND A LONG-TERM PROGRAM IN EARTH CRUSTAL DYNAMICS, WITH SPECIAL EMPHASIS ON THE ROLE OF OCEAN DRILLING. THAT COMMITTEE MET IN FEBRUARY.

BASED ON THE DISCUSSION AT THAT MEETING IT APPEARS THAT THEY WILL RECOMMEND THAT WE CONTINUE OCEAN DRILLING, PREFERABLY WITH A MODERN LEASED COMMERCIAL DRILL SHIP. BECAUSE OF RECENT CHANGES IN OIL EXPLORATION BUSINESS, IT APPEARS THAT A SHIP CAN NOW BE LEASED AT A MUCH LOWER COST THAN CONVERTING THE EXPLORER. THERE ARE MANY ASPECTS OF THIS IDEA THAT NEED TO BE PONDERED. WHEN THAT COMMITTEE MAKES ITS FINAL REPORT AVAILABLE I WILL CONSIDER IT AND DISCUSS IT WITH THE NATIONAL SCIENCE BOARD, WITH DR. KEYWORTH, AND WITH THE CONGRESS.

Now let me mention a very important national program: the U.S. Antarctic effort. In February 1982 the President issued a decision memorandum which stated that the Foundation is to continue to budget for and manage the entire U.S. national presence on the Antarctic continent--and that this program is not to be funded at the expense of other National Science Foundation programs. Our efforts in 1984 will entail support for research projects in several fields of science, and for improvements to the facilities that are critical to the conduct of a safe and effective research program and to the maintenance of an active and influential U.S. presence there.

Cross Disciplinary Programs

In addition to the programs of support for work in various research disciplines, the Foundation has a number of other programs which cut across the concerns of all disciplines and have an important bearing on their overall health and vitality. These programs, which address such activities as research at undergraduate institutions, international cooperative research, and expanded participation of women and minorities in scientific careers, have generally been treated as "set asides."

BEGINNING IN FY 1984, RESEARCH PROGRAM OFFICERS WILL BE REQUIRED TO ADOPT A MUCH BROADER VIEW OF THEIR RESPONSIBILITIES TOWARD THE HEALTH OF SCIENCE. OUR BUDGET REQUEST ANTICIPATES THAT THESE "SET ASIDE" PROGRAMS WILL BE INTEGRATED, BUDGETARILY AND MANAGERIALLY, INTO THE MAINSTREAM OF THE FOUNDATION'S RESEARCH ACTIVITIES.

THERE IS A PERCEPTION BY SOME THAT THE QUALITY CONTROL IS NOT AS GOOD AS IT IS IN THE MAINLINE RESEARCH PROGRAMS. THERE IS ALSO THE FEELING WITHIN THE FOUNDATION THAT ONE PURPOSE OF SUCH PROGRAMS, NAMELY TO FAMILIARIZE TARGETED GROUPS WITH MAINLINE RESEARCH FUNDING PROCEDURES, HAS NOT BEEN MET, BECAUSE THESE TARGETED GROUPS ARE NOT INTRODUCED TO, NOR DO THEY WORK WITH, THE RELEVANT DISCIPLINARY RESEARCH PROGRAM OFFICERS. THUS, SEPARATE MANAGEMENT HAS MADE BRINGING THESE TARGETED GROUPS AND INSTITUTIONS INTO THE MAINSTREAM OF RESEARCH MORE, NOT LESS, DIFFICULT. AND, FINALLY, THE VERY EXISTENCE OF SPECIAL PROGRAMS CONVEYS AN IMPRESSION TO THE MINDS OF PROGRAM OFFICERS THAT THESE TARGETED ISSUES ARE SOMEHOW BEYOND THEIR PURVIEW IN GRANT AWARD DECISIONS, DESPITE THE CLEAR BEARING OF THESE ISSUES ON THE HEALTH OF SCIENCE AND ENGINEERING.

THE INTEGRATION OF THESE ACTIVITIES INTO THE MAINLINE RESEARCH PROGRAMS OF NSF IN FY 1984, I BELIEVE, WILL ENHANCE--GREATLY AND MORE PERMANENTLY--OUR SUPPORT OF WOMEN, MINORITY, UNDERGRADUATE FACULTY RESEARCH, AND INTERNATIONAL ACTIVITIES IN THE FOUNDATION. IT WILL ALSO FURTHER OUR GOAL OF BROADENING THE ATTENTION OF THE FOUNDATION TO THE OVERALL HEALTH OF SCIENCE AND TECHNOLOGY IN THE U.S.

Conclusion

The intellectual state of science in this country is good. American science is the envy of the world. During the last three and a half decades the United States has had more Nobel Prize winners in science than any other country. And in mathematics the skill of American researchers was again affirmed by the award of two of the last three Field Medals to Americans. Today the United States has more scientists and engineers engaged in research and development than any other nation in the western world. We are winning medals and Nobel Prizes now. But what of the future? Where will we be in science twenty years from now?

We are being challenged by an economy that is in a time of great technological transition.

We are being challenged by the weakened position of the United States in world markets.

We are being challenged by a need to maintain our national security.

These challenges require a greater effort in scientific research, a major improvement in the instruments used in university laboratories, and an increase in our scientific manpower in certain fields. The FY 1984 NSF budget will help to address these needs.

Over the three decades of the Foundation's existence, our budgets have had strong bipartisan and public support. I believe we have a strong, well conceived budget proposed here that is once again worthy of your approval. For my part, I will work with the National Science Board, with Foundation staff, and with the research community to see to it that support of excellence through competition continues to be the goal in all the Foundation's programs.

The CHAIRMAN. Thank you, Dr. Knapp.
We will now turn to Dr. Branscomb.

STATEMENT OF DR. LEWIS M. BRANSCOMB, CHAIRMAN, NATIONAL SCIENCE BOARD

Dr. BRANSCOMB. Thank you, Senator Hatch. I am Lewis Branscomb, vice president and chief scientist of the International Business Machines Corp. and Chairman of the National Science Board. With your permission, I would like to put into the record my written testimony.

The CHAIRMAN. Without objection, we will put all formal statements into the record. We do appreciate summarization.

Dr. BRANSCOMB. I am optimistic about the future of this country in part, because there is clearly now a consensus across the political spectrum—the President, the Congress, and the people—that we have found what should be the long-term strategy for national competitiveness and economic health. It is the combination of the technology base and the competitiveness of industry, the education base for the production of young people, and the knowledge base that comes from research. There may be some differences in details or strategy, but I think Americans are at one with themselves on that issue.

Some years ago, after the Russian sputnik, we had a similar focus of national attention on this set of questions, and the Congress and the American people responded to that challenge. However, I believe there is a fundamental difference between the situation today and the situation at that time which gives me confidence that instead of this interest flagging, as it did in the years after sputnik, it will be a new dedication to excellence in this country.

The difference is that in the sputnik era the American people were called upon for national effort to meet an international challenge for which the Federal Government was the essential responder through the Apollo program and similar activities.

Today, I think Americans realize that we still have an international challenge, both on the security side and on the economic side, but that that challenge must be met in the neighborhoods and communities of this country. It is not a challenge to be assumed for the community by the Federal Government. For that reason, I think there is an understanding of the relationship between science, education, and economic health; it is understood as a community and State issue. And it is for that reason that I feel the country is now ready for an investment program that will be sustained not just in 1 year but over a period of years.

This NSF budget is a strong budget. It meets with vigor a number of critical areas in research and in education. It will do the job for the country if we do our job well in carrying out the responsibilities under it, but also if this dedication is continued for a period of time.

The National Science Board is a hard-working group of scientists and engineers who have shaped the priorities in this budget through long deliberations. My prepared testimony describes that process, whereby the Board and the Director, who of course is a

prominent member of the Board, work together to achieve the consequence you have before you.

There are many specifics in this budget. I could cite engineering, mathematics, plant biology. Many other areas have been carefully constructed and thought through. The increases requested in the authorization are based on the highest priority and thoroughly feasible opportunities for the country.

Perhaps most important of all, this budget seeks to insure that the scientists and engineers who are supported by it can work at a fully effective and efficient level of application of their talents. What that has required in recent years is adequate equipment and instrumentation for academic scientists, who are not equipped today the way their industrial counterparts are. Instrumentation is an important part of the programs in this budget.

We are also pleased that this budget requests the opportunity to continue the science education activities begun in fiscal year 1983 at the precollege level. And I am pleased that your committee will have a hearing devoted specifically to the educational activities of this budget. They are important at the university, college, and precollege levels.

While NSF focuses its priorities on basic science as the important contribution the Federal Government should make to this national strategy, we do not ignore the effective mechanisms that cause sometimes abstract and sophisticated research to come swiftly to the practical advantage of American citizens.

To me, the most important linkage is the linkage between the universities and the private industry engineers and scientists. About a month ago, the Board transmitted to the President, and he transmitted to the Congress, a report on university-industry research relationships. I believe your committee has received it. The report describes in some detail the problems and the successes—the successes far outweigh the problems—of collaborative relationships between universities and industry. This is an area that is growing apace. They are healthy, vital, dynamic relationships. While it is not the Federal Government's role to orchestrate these relationships, it is NSF's role to stimulate them and to take great satisfaction in their health. Through these relationships, this Congress can be comfortable that as it invests in long-range academic science and engineering, it is investing in practical outputs from the private sector. And those outputs follow from the strong relationships unique to this country, that no other country enjoys, between the universities and private industries.

Finally, let me say that the Board has taken great pleasure and satisfaction in working with Dr. Knapp, the new Director. He is providing leadership that the Board respects highly. I want to say personally what a pleasure it is for me to see the National Science Foundation in such able hands.

[The prepared statement of Dr. Branscomb follows:]

STATEMENT OF
DR. LEWIS M. BRANSCOMB
CHAIRMAN, NATIONAL SCIENCE BOARD
BEFORE THE
COMMITTEE ON LABOR AND HUMAN RESOURCES
U.S. SENATE
MARCH 18, 1983

Mr. Chairman and Members of the Subcommittee,

I am Lewis M. Branscomb, Chairman of the National Science Board. It is my pleasure to appear before you today to discuss the authorization of the FY 1984 budget for the National Science Foundation.

I will summarize the Board's role in the construction of this budget and discuss some of the Board's activities during the last year that have a bearing on the strategy behind this budget, the priorities in it and the policy issues that are attached to its implementation. I will be brief in order to leave as much time as possible for your questions.

The President's 1984 budget attaches a high priority to the task of strengthening the academic science and engineering base on which the nation's economic and military security depend. A very substantial increase in basic research funding is requested at a time when all of us are eager to see the federal budget gap closed and every unnecessary federal expenditure eliminated. I urge the Committee to authorize the full amount requested for the Foundation in this budget. In so doing, I assure the Subcommittee that the National Science Board has weighed very carefully the priorities in this budget and is persuaded that the investments proposed are indeed necessary. Furthermore, we are confident that the monies

will be spent wisely, through the well-respected competitive review system that the Foundation has used for more than thirty years.

The people of this country are eager to see the economic vitality of the United State rekindled and agree with the President's emphasis on retaining leadership in science and technology as an important element of economic strategy. The private sector should be expected to make its own investments in research and development, production and service technology. The National Science Foundation's proper role is to support advances in science and engineering that lie beyond the horizons of most companies, to encourage the highest quality of education in scientific and engineering research and practice, and to help improve the teaching of mathematics and science in secondary schools where it can do so with high leverage and in support of community goals. In order to accelerate the contribution of the resulting knowledge and skill to the economy, the Board also encourages close and voluntary collaboration between university and private company researchers. The Foundation has been active in all these areas this past year. I will note the highlights. First let me speak to research priorities.

The budget reflects the emphasis that the Board has placed for several years on investments in equipment and people to work in the physical sciences and engineering. But we are pleased that this budget permits a balanced strengthening of all fields of science, while focusing on specific areas that are ripe for rapid advancement, that offer special benefits if successful, and that address the most urgent needs for rebuilding of facilities, instrumentation, and equipment.

The budget reflects Board efforts to give particular attention to several matters. In 1981 the Board devoted its primary policy development efforts to clarifying NSF's role in supporting science and engineering education, to the adequacy and emphasis of support in the social and behavioral sciences, and to the academic research community's needs for research instrumentation and equipment. The Board provided policy guidance to the staff in all three areas. In August 1981 the Board adopted a statement of policy and program priority on science and engineering education, and approved the same day the Director's implementation plans. This work provided the basis for the subsequent establishment of the Board's Commission and identified the kinds of program activities in precollege math and science education that are appropriate for NSF.

In 1982 we paid special attention to opportunities and policy issues in engineering, the plant sciences, computer-related research, and international science. Our work on science education evolved as the Board's Commission on Pre-College Education in Mathematics, Science and Technology went to work.

The present budget request would permit a significant number of critical needs to be addressed. Let me give you some examples: A substantial portion of the new funds will go to modernization of scientific equipment. The strategy of including these funds within the budgets of the several directorates will help ensure that the new funds go only where the merit of the proposed new work is very high. The new equipment will be applied in just those project areas with the highest potential for scientific payoff. This rebuilding of the universities' laboratories will have to be

continued for a number of years before the level of modernization is even equal to that typical of industrial research. University laboratories, of course, should be working well beyond the forefront of industrial research; they should have access to even more sophisticated facilities and equipment.

The field of mathematics has been neglected for a number of years, and the field has historically been a magnet for the most brilliant young people. The vitality of the field has suffered and needs some rebuilding. So too do selected areas in the social sciences, identified in the Board's policy statement last year.

Plant biology has been recognized as an opportunity area for American science that can have only scientific and economic benefits of a high order. The molecular biology advances of recent years provide the point of departure, but cellular and developmental biology, and the biochemistry of plants are receiving attention from only a handful of leading laboratories. Yet the new scientific findings from these laboratories encourage the belief that a whole new knowledge base for a revolution in agriculture and in natural products technology can be ours. The anomaly of this small effort in the face of the very exciting research possibilities results from two facts. First, the manipulation and cloning of plant cells are often harder than for living animals; techniques are not yet fully available. Second, research funding has centered principally on health-oriented agencies, which are, because of their roles and missions, more interested in human physiology than in plants.

Engineering is in the middle of a revolution, brought about by new technology (the computer, thus simulation; graphics design

and robotics) and by a new urgency (the demonstrated ability of Japan to use a large, well-trained engineering force to produce goods of higher quality and lower cost than many U.S. firms provide.) Concurrently, the Board sees striking reasons to invest in research in computer science, in electrical and computer engineering, in the application of new information technologies, and in addressing the most urgent problems in education in computer skills.

These examples will serve to illustrate something of the nature of the National Science Board's impact on budget priorities. The process begins each year in the late fall and winter when teams of Board members discuss priorities with the Director and with Assistant Directors and other senior staff of each of the disciplinary areas. We also look at special issues, such as the state of science education, capital facilities, and international opportunities. In February and March, we discuss long-range plans and programs priorities. Furthermore, the most important issues that emerge make up the agenda for the Board's June meeting, which is devoted exclusively to full discussion of two or three major topics. All this work is reflected in the NSF's budget submission to the OMB in August. At that stage, the budget is jointly recommended to the President by the Director and the Board. This work is, of course, done within the context of the overall policy framework established by the President and the Congress, and the final budget request to Congress follows from the President's final decisions.

Now let me turn to education in the sciences and engineering. As I said above, the responsibility for college-level education is placed within the operating Directorates. We continue to concentrate the majority of our resources on research in college and university laboratories, for there we not only find superb talent willing to compete for support with their best ideas, but, by following this policy, we also help support the training of some 10,000 graduate students in the most rewarding fields. This student support complements fellowship support, which continues to be a vital component in the total strategy for providing the next generation of scientists and engineers. For FY 1984, we are beginning a new initiative to encourage younger research faculty in shortage categories. Dr. Knapp will be discussing that.

Two precollege initiatives will provide an important contribution to the encouragement of excellence in math and science teaching and in improving the professional capabilities of math and science teachers. The dimensions of the problems facing the Nation's schools in these areas are now well known. The Board's Commission has been carrying out its work with the intent of stimulating the broadest awareness of this issue and actions to address it; it has been quite successful in my opinion. A great variety of activities, by professional societies, business leaders, Governors, and especially the school systems themselves are now being generated.

We expect the Commission to complete its work in October, and the Board is arranging its own plans to act quickly on the Commission's recommendations. The form of these conclusions should

begin to become clear later this spring, for the Commission is carrying out its work quite publicly, encouraging feedback from citizens and teachers in the towns where the Commission meets. The Board believes, as it said in August 1981, that the NSF can and must play a leadership and catalytic role in the national effort to solve this problem. This is a very important subject on the nation's economic agenda; we are making a significant start in this budget.

Let me make two other points about the NSF program in 1984. The Board's 14th report to the President and Congress (which you have recently received) is on the topic University-Industry Research Relations: Myths, Realities and Potentials. It describes a dynamic situation with a rapid growth of scientific and engineering collaboration, which will surely accelerate the evolution of new research ideas into the economy, and help industry to be more innovative and competitive. Even before the report was completed, rapid expansion in the number of such collaborations has been reported. NSF's early encouragement helped trigger this development, but it is driven by natural forces that will be very good for both groups of institutions. This phenomenon should make the Congress even more confident that the investment you make in university research will indeed be an investment in jobs and a better life for our people.

Second, let me call attention to the Board's consideration of international science issues. Increasingly we need to help U.S. scientists get access to field sites abroad for scientific study; we need to be able to build collaborative relations with the increasingly strong scientific groups in countries like

Germany and Japan; and we need to be able to jointly plan major research facilities which are increasingly difficult to fund for the exclusive use of one country. The Board's policy statement of last September will guide the Directorates as they take responsibility for both domestic and international aspects of their fields of science and engineering, with the help of the International Division and the guidance of the Department of State. The Board does not expect the new way of managing to diminish the importance of international relations in science; indeed we seek to make them more tightly coupled to the U.S. interest in science, which includes the need for a free and productive world scientific community.

Finally, let me note that a science policy--American-oriented to economic as well as national security goals--is emerging and is reflected in the plans of the Foundation. I feel very optimistic about the future.

Thank you.

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The CHAIRMAN. Thank you. It is a pleasure for us as well.

I might mention that we will keep the record open so that any Senator on this committee can submit any questions he desires in written form and so that we can continue to build this record.

I do have a few questions for you.

In your testimony, Dr. Knapp, you state that the NSF has been funding about 10,000 of the approximately 27,000 proposals it receives each year. How do you expect the substantial increase the President has recommended to affect that ratio? Will you give greater support and maintain the highest quality or will you keep the average grant amount the same and increase the number of awards?

Dr. KNAPP. We will do both. The first priority in the grants programs at the Foundation is to rectify a serious problem in instrumentation in the colleges and universities of this country. It is a problem because the grant size during the past few years has been inadequate to purchase the instrumentation necessary for research. The grant size also has been too small to support adequately the number of graduate students and postdoctoral fellows needed in research.

The first priority at NSF will be to establish the grant size so that the Foundation can meet its responsibility to maintain the quality of research in this country as high as it can be.

The fiscal year 1984 increase will also be used, where possible, to make more research awards where we can do a responsible job of adequate funding can be done in the award to carry out the research.

The CHAIRMAN. Thank you.

Does the Foundation receive sufficient proposals which are judged excellent by the peer reviewers to justify the large increase the President has recommended?

Dr. KNAPP. Yes. The cutoff level, as we call it, in the Foundation for most, if not all, of the scientific disciplines is uncomfortably high. We are not funding some proposals which are really excellent science.

The CHAIRMAN. Some years ago I tried to get the NSF to tell me the number of proposals that it received but could not fund which were judged good to excellent. I was told that the Foundation did not keep that statistic; that each subactivity would have to count literally its individual files. Therefore, I assume that your management information system now has that capacity. Am I right?

Dr. KNAPP. Yes. The management information system can have that capacity. Unfortunately, the peer review process is much more complicated than adding up goods and excellents and coming up with some average grade. It is not quite like going to school.

The CHAIRMAN. Sure.

Dr. KNAPP. The judgment of what is good and what is excellent is subjective and depends upon the number of proposals and other intangible features.

The CHAIRMAN. Obviously, the number of qualified proposals that you have received but cannot fund would be very helpful information in helping us to determine what the ultimate budget or what the budget increases in future years should be for NSF.

Therefore, I hope that you will work toward that end. I understand the complexities and difficulties involved.

Dr. KNAPP. I will investigate whether I can supply that number for the record for this testimony.

The CHAIRMAN. What is your intention regarding the science and technology to aid the handicapped program?

Dr. KNAPP. My intentions are to continue and to increase that program. In the budget for fiscal year 1984, that program has been increased from $2 to $2.3 million in the engineering directorate. This is a program in which the leadership of the engineering directorate is interested; I believe that management will do all it can to continue the active expansion of this program.

The CHAIRMAN. My understanding is that this program has not been properly staffed. It is of great concern to all the members of this committee, particularly Senators Randolph, Pell, Stafford, Weicker, and myself. Therefore, we will look forward to seeing what you can do there.

NSF has indicated it will spend a good deal of money on massive research facilities such as the Cornell accelerator and the very long baseline array telescope you described in your statement. Are these facilities available to all scientists or are they restricted for the exclusive use of researchers in the particular institutions where they are located?

Dr. KNAPP. In all cases of large facilities, such as the Cornell electron-syncrotron and the VLA, the facility is available to all scientists of any institution, subject to a proposal submitted to the operating institution and judgment by scientific peers.

The CHAIRMAN. Let me turn to you, Dr. Branscomb. I do not want to dominate the question time here, but let me ask you just a couple questions.

You mention the peer review system in your statement. I agree with you that this appears to be the most effective way to determine what are the most meritorious proposals. I wonder, however, if the peer review system has ever been critically evaluated by the National Science Board to see if there is any way, or ways, to improve it. I do not believe that any Government procedure, even a successful one, should be so sacred that we ignore possible ways to improve it or to make it more economic.

Dr. BRANSCOMB. We have, indeed, Mr. Chairman. In fact, the peer review system at the NSF is not at all a static process. It has changed substantially over the years. We, of course, gave the subject special attention when the Foundation contracted with the National Academy of Sciences for a specific study of the peer review system. At that time we went into some detail, both as to the content of the analysis done in that Academy study and a review of the process within the Foundation. While many people found some of the popular interpretations of the Academy study to be somewhat fallacious or misleading, it is also true that there were shortcomings. The system was not perfect. Some corrections were installed by the Foundation, even before the report was finished.

The CHAIRMAN. We appreciate that.

Dr. BRANSCOMB. Let me make a further comment, if I may.

The CHAIRMAN. Go ahead.

Dr. BRANSCOMB. As we try to perfect the peer review system, we should appreciate that the system is not a substitute for the responsible, professionally informed judgment of the program officers of the Foundation. As you probably know, I spent some years in Government service myself. I was Director of the National Bureau of Standards. I have the highest regard for the intelligence and, most importantly, the commitment to the public interest of the technical professionals in this Government. It is the NSF program officer who ultimately makes the judgment that this or that grant is in the public interest. He or she would do so with great reluctance if the peer reviews were poor. The program officers would be greatly reassured if the peer reviews were all superb. However, ultimately, the program officers must make that judgment.

You have a right to expect that the agency is responsible for the final judgments, that NSF does not simply put it off on a vote of the peer reviewers.

The CHAIRMAN. Thank you.

Dr. Knapp, I have just one final question for you.

In your testimony you indicate that you will pursue a new management style with respect to those programs which go across the separate research directorates. You should know that the reason some of the programs have been set apart, or for which we have legislated set-asides is because we in the Congress were not convinced that the Foundation would carry them out otherwise. What assurances can you give us that these programs will not be shortchanged if they are integrated with the directorates and implemented across the board?

Dr. KNAPP. I have asked the Assistant Directors of the Foundation as a committee to develop for me a management plan to insure accountability of the moneys spent in these programs. We will not go forward with this management plan unless I am convinced that NSF can assure the Congress that the moneys set aside for these programs are being spent for the intended purpose.

The CHAIRMAN. All right. Thank you. I really appreciate that.

Senator Pell.

Senator PELL. Thank you very much, Mr. Chairman.

I am not sure whether this question should be addressed to Dr. Knapp or Dr. Branscomb, but what is the number of vessels in your research fleet, your oceanographic research fleet?

Dr. KNAPP. Excuse me.

Senator PELL. How many vessels do you have engaged in oceanographic research?

Here I would say we are extremely grateful to the National Science Foundation for the one that is in use at the University of Rhode Island.

Dr. KNAPP. I am not familiar with the exact number of vessels in the oceanographic fleet, but I can provide that for the record.

Dr. Branscomb, do you have a figure?

Dr. BRANSCOMB. No.

Dr. EDEN. Twenty-four.

Senator PELL. Twenty-four. How are they divided between the east coast and the west coast? Half and half?

Dr. EDEN. We can provide that for the record. It is equally distributed among some 10 or 12 institutions.

The academic fleet now consists of 25 ships. Of these, 11 are located on the west coast, 12 are on the east coast, and 2 are on the gulf coast.

Senator PELL. I know that I am very delighted that you are in this program. Speaking for my own State, I want to express my full support, obviously.

Another question on another subject, the metric system: Do you believe that the United States would be better advantaged or disadvantaged if we moved toward a more universal metric system?

Dr. BRANSCOMB. The United States is moving toward the adoption of what is conventionally called the metric system, "The International System of Units." It is, in fact, the legal basis for our measurement system, and has been for many years. However, I have never been an advocate of Government compulsion on the use of it in everyday life. Indeed, Government's role is to insure that the public is properly informed, that the Government itself does not constitute an obstacle to the natural economic forces leading companies and other organizations into adopting it when it is in their interest to do so. I think the facts show that that trend has been underway for many years and continues.

Senator PELL. However, in my view, in the past couple years we have gone in reverse. The Metric Council has been dissolved. As you know, the Metric Council was more a research organization. It kept the information available. The signs that used to be on the road giving distances in kilometers have been removed. Generally, it seems to me that we are moving in an opposite direction from what you say, Dr. Branscomb; that we are going backward.

Dr. BRANSCOMB. Perhaps there is less public conviction on this subject than there was a few years ago, but the public's interest in the Nation's posture in technology also has declined recently. It was strong 10 years ago, as a consequence of Sputnik, and Apollo. It is now reviving. As people come to appreciate that international economic competition sets the gauge by which we determine the domestic productivity levels, we will discover that being the only substantial country that does not use a simple and common system of measurement with the rest of the world does exact a price. And enterprises will urge community support for appreciation of this change.

Senator PELL. Do you happen to recall what the other countries are that share with us——

Dr. BRANSCOMB. I remember Burma and Yemen I am not sure I remember the others.

Senator PELL. I believe there are two more, which perhaps you can submit for the record.

[Information referred to follows:]

In addition to the United States, the following countries do not use the metric system: Burma, Brunei, North and South Yemen.

Senator PELL. I would hope that our industrial potential, industrial drive, would more equal those countries that are not this small group but in the larger group.

Why is it that Great Britain has left the metric system and we have persisted in being on the English system?

Dr. BRANSCOMB. The British—you said, "left the metric system." I think you meant——

Senator PELL. I am sorry, left the English system and brought in the metric.

Dr. BRANSCOMB. They obviously have a broader consciousness of their economic trading relationships, particularly in the Common Market. A bigger fraction of the British economy is in international trade than is the United States. This leads to a greater consciousness of the issue.

However, I believe that the U.S. dependency on international trade is growing rapidly, and the dependency is more important than simply the percentage of GNP devoted to it. And that dependency relates to penetration of U.S. markets by foreign producers and U.S. opportunities to sell abroad. The consciousness will grow here, but in most States today the majority of the economic activity is within the State or within the region. Until recently, it has not been that much affected by foreign imports.

Senator PELL. I know it is very unpopular. I have taken something of a leadership position in this in the past. I think the only way we are ever going to move in this direction is if more people in the Government and more people in leadership positions put themselves behind this very unpopular step. It is an unpopular step. I know that from personal experience. However, I think it is right.

Basically, I do not want to embarrass you vis-a-vis the administration, but let me put it this way: I am sure you do not think it is wrong to go on the metric system.

Dr. BRANSCOMB. No, I certainly do not. The National Productivity Advisory Committee, which the President appointed and on which I serve, unanimously recommended last year that since the activities of the National Metric Board were being picked up by the Commerce Department, it was important for the Department to provide technical support to the voluntary efforts of the private sector to move ahead in this area and to provide information on request. The recommendation does suggest that it is the private sector's role to exhort people to this goal, rather than the Federal Government's role.

Senator PELL. However, I wish somebody in the Government—maybe you—would say publicly that it is to the advantage of the United States to go metric. I have not seen that statement made under this administration. Have you?

Dr. BRANSCOMB. No, sir, and I am not the spokesman for the Administration on this subject; the Secretary of Commerce is.

Senator PELL. Are you familiar with my education for economic security proposal that is a bill that calls for the expenditure of about $400 million, two-thirds for schools, one-third for colleges, in math and science?

Dr. BRANSCOMB. Yes, sir, in general.

Senator PELL. Would you feel that—well, put it another way. I notice that your own precollege teacher improvement program focuses exclusively on the math and science teachers at the high school level, but a majority of the elementary school teachers in our country have very little training here. Yet, a number of studies have shown that youngsters' interest drops off in the third and fourth grades. Shouldn't we be focusing more on the elementary

school teachers? Shouldn't my bill maybe bring something in of that sort?

Dr. BRANSCOMB. It would be wise if the legislation were open and even-handed with respect to kindergarten through grade 12. There are important things to be done throughout that range.

If I may make a comment in behalf of my company, not the Science Foundation, IBM has some interesting experience with the use of personal computers to teach children how to read and write in kindergarten and first grade. It seems to work very well.

In that respect, I think you are correct. I believe that the Science Foundation's past activities in precollege mathematics and science have also touched that area, perhaps not so much in teacher training as in the television activities formerly sponsored by, the Foundation.

Senator PELL. Similarly, along the same lines, as you know, many schools have inadequate instructional material. Many schools lack math and science teachers. Will you be focusing on resolving this problem in any way from the NSF viewpoint?

Dr. BRANSCOMB. I think that is a good question for Dr. Knapp.

Dr. KNAPP. The program that we are developing for precollege science education has elementary school aspects. NSF's part of the program—it is divided between the Department of Education and the Foundation—focuses on those things which we feel we can do best at NSF. We attempt to use NSF grantees in direct contact with teachers to develop new materials for teaching of science, both for teaching teachers and teaching students. We do not restrict our activities to the high school and junior high school. We expect to help with this problem through the entire school system.

Senator PELL. Dr. Knapp, the 1984 budget for the EPA includes a transfer to NSF of $4 million to carry out the EPA exploratory research program. Could you give us an idea of what these funds will be used for and how EPA—rather, not how, but who at EPA, and that is rather difficult in these days of changing individuals there—who you foresee overseeing this program and what the relationship will be to the Superfund?

Dr. KNAPP. At present, these funds will not be transferred to the Foundation, and NSF will have no activity in that area. That is a fairly recent development.

Senator PELL. The budget proposal, I think, includes a transfer to you of $4 million; is that correct?

Dr. KNAPP. I don't think so.

Senator PELL. Then I have been misinformed.

Thank you.

My final question is this: One area of NSF's support that I have followed closely is the availability of funds for science museums. In the past moneys have been available under your program known as the public understanding of science. Could you bring me up to date on NSF museum support?

Dr. KNAPP. The museum support in fiscal year 1983 will be included in the revised plan which will be sent forward to Senator Garn's committee. The plan includes use of the $15 million appropriated for science education.

Senator PELL. Could you repeat that? I am sorry.

Dr. KNAPP. In fiscal year 1983, support for museums and the public understanding of science is included in a revised program plan for science education. The plan is to be considered in the next few weeks by Senator Garn's committee.

Senator PELL. In other words, science museums will be supported to a degree by you, by the NSF, about to what degree?

Dr. KNAPP. The levels are part of the negotiation with the committee.

Senator PELL. Can you give me an idea of the range?

Dr. KNAPP. We do not have a resolution of this problem of NSF's plan with the Congress, but we are rapidly coming to one. If my recollection is correct, what we will propose is not a great deal of money but adequate to keep the program alive.

Senator PELL. Right. Anyway, I would like you to be aware of those of us on the Subcommittee on Education, Arts, and the Humanities—we are very interested, indeed, in seeing more support for science museums. I would hope you would do your very best in this regard.

Dr. BRANSCOMB. Your interest in the advancement of science museums is shared by many members of the National Science Board, and certainly myself. One of our philosophical points of view is that as activities are developed to assist in the training of teachers and the provision of materials for teachers, many institutions can play a useful role, including science museums. We probably should try to arrange the programs with enough flexibility so that we do not predefine the precise characteristics of institutions that can assist in solving the mathematics and science education problems in kindergarten through grade 12. To that extent, the participation of science museums versus other forms of institutions would depend upon the proposal received rather than some characterization, I should imagine.

Dr. KNAPP. Perhaps I could expand a little on my answer, since it perhaps was not clear. An additional $15 million was placed in NSF's budget by the Congress for science education activities in fiscal year 1983. The use of that $15 million was to be contingent upon approval of an NSF plan by the Congress. These funds are in the plan which is not yet approved.

Senator PELL. Thank you.

Just returning for a moment to the $4 million transfer, my reason for that statement is that in the document I think you submitted, the administration submitted, it says, "The agency"—that is EPA—"will transfer $4 million to NSF in 1984 for new grants. The agency—EPA—"will work closely with NSF to assure that these grants are tailored to a long-range strategy."

Dr. KNAPP. That is the EPA budget; is that correct?

Senator PELL. Yes.

Dr. KNAPP. This transfer never appeared in NSF's budget. A letter written by Mr. Hernandez, about 1 week or 2 weeks ago to the OMB, requested that the transfer not take place.

Senator PELL. I see. Thank you very much.

Thank you, Mr. Chairman, for your indulgence.

The CHAIRMAN. Thank you, Senator Pell.

We want to thank both of you gentlemen for the excellent leadership you are providing. We are very pleased that the NSF is

being significantly beefed up, this year. We appreciate your appearing here today and giving us your excellent testimony.

Thank you so much.

Dr. KNAPP. Thank you.

Dr. BRANSCOMB. Thank you.

Senator PELL. Amen.

[Responses of Dr. Knapp to questions asked follow:]

Responses of Dr. Edward Knapp to Questions Submitted by Sen. Kennedy

Women and Minorities

Statement: Dr. Knapp, I played a major role in the enactment of the Equal Opportunities in Science and Technology Act of 1980. I am dismayed at how few programs have been offered by the NSF to meet the requirements of the act. Less than 1% of NSF's budget is spent on these programs. None of the almost $200 million increase will go to programs for women and minorities.

As Director you have a responsibility and legislative mandate to develop America's human talent, regardless of race, gender or handicap, to its fullest potential to do first class basic research.

Question: How do you intend to fulfill this obligation?

Answer: Human talent is the most precious scientific resource which this Nation possesses. I look forward to the day when every young man and woman, regardless of race, is able to realize his or her full potential. We can only benefit from such a condition. I am fully, personally committed to the achievement of such a state of affairs.

The Foundation has several strong programs that are targeted to the support of research by women and minority scientists and to strengthening the research capabilities of those historically minority universities with graduate programs in science or engineering. In addition, these same individuals can and do compete for support in the Foundation's other activities. The budget levels for t[illegible] targeted programs are based on our experience with the number and quality of proposals which we have received in the past.

In FY 1982, the Minority Research Initiation program received 30 proposals and funded 16 of them at a total of $1.4 million. A similar level is estimated for FY 1983. In both years it has been possible to support all of

the strongest proposals. Because the response was so strong to the Visiting Professorships for Women program in the first year of its operation, FY 1982, an additional amount of over $400K was added to the total originally planned for the program to enable us to support all of the proposals we received. This program is aimed at encouraging careers for women in science and engineering. In FY 1984, support will equal $1.5 million, level with FY 1983, but an increase of $600K over FY 1982.

The Research Improvement in Minority Institutions program provided support to predominantly minority universities with graduate science and engineering programs. Awards were given to 4 institutions in the first year of its operation to a total of $900K. There are 30 institutions eligible for NSF support under the program and we anticipate an additional 8 awards to 5 additional institutions in FY 1983 for a total of $2 million. A similar level is proposed in FY 1984.

Question: Why has none of the almost 18% increase gone for these programs?

Answer: The Foundation's commitment to increasing the participation of women and minorities in science and engineering research careers extends far beyond these focused programs. During the past few months, a group of my top Foundation managers have thoroughly reviewed these programs and have reinforced my intentions to make certain that they are more closely tied to our mainstream research activities. In the long run, I firmly believe that support for women and minorities will expand as they have opportunities to interact directly with all of our research program officers. I have charged these program officers with a responsibility for reaching out to these groups and for taking their needs and capabilities into account in meeting NSF responsibilities for the overall health of science.

Statement: Dr. Knapp, last month, the NSF reported that although there was an increase in the number of blacks employed as scientists and engineers in 1981 over 1980, only 2 percent of all employed scientists and engineers were black, only 13% were women.

Furthermore, the NSF reported that of full-time graduate students in 1980, less than 4 percent were black.

Question: Don't you think these numbers suggest that $4 million proposed for blacks and other minorities in the NSF budget is inadequate? Why haven't you asked for more?

Answer: I believe that our present request is adequate to meet the needs of these programs as they are now structured. Our existing programs are focused on those aspects of the participation of women and minority scientists in research careers to which I believe the Foundation is best qualified to respond. As we gain broader experience with the needs and capabilities of such individuals by tying these programs much more closely than at present to the central disciplinary research activities of NSF, I am quite confident that we will do an even better job of responding to them. It is not inconceivable that this may also result in a broader set of programs and more resources for them. If so, this will occur in the context of the needs of scientists and engineers in each discipline and NSF program.

Question: What do you think it will take to close this gap for women and minorities?

Answer: I don't think that we can generalize about strategies for increasing the proportions of minorities and women in the scientific and engineering labor force. We know that these proportions, overall, are much lower than they ought to be if the human potential for scientific careers among these groups were being fully realized. There is no doubt, in my opinion, that science, and our Nation, are the losers because of this.

The situation of women in this labor force -- the barrier, opportunities, interests, motivations -- is generally quite different from what it is for minorities. Some fields of science, for example the social, behavioral and biological sciences, attract many more women than do others, including engineering. We also have the phenomena of women, trained as scientists, dropping out of the labor force for child bearing and child rearing. The labor force and educational dynamics are obviously different for minorities.

Indeed, it is probably the case that minorities -- Blacks, Hispanic-Americans, Native Americans, Orientals, -- differ markedly in their needs, educational problems, career aspirations and the like. No simple generalization about increasing participation of these groups in the scientific labor force is very meaningful. It is a highly desirable objective, one I fully endorse. Its realization will be slow and difficult, and the steps we take must reflect the diversity of the needs and situations which exist.

The Foundation can be only a small though, I believe, potentially significant factor in achieving this national objective. It will be small because its resources are limited and are best focused on what it knows and does best -- supporting quality scientific research and the graduate education attendant on it. It will also be small because the problems are extremely complex and involve the interests, needs, and actions of numerous public and private groups and organizations. It will be significant, however, because of the key role which NSF plays in the basic scientific and engineering enterprise in this country.

Knapp Management

Statement: There have been reports that the White House agreed to the proposed budget increases for NSF only after you agreed to fire two senior deputies.

Answer: The proposed budget increase for the NSF was in no way related to or contingent on my decision to request the resignation of Dr. Donald N. Langenberg and Dr. Eloise E. Clark. These were completely independent events.

Question: Dr. Knapp, did officials at the White House request that you seek the resignation of Deputy Director, Donald N. Langenberg and of Assistant Director Eloise E. Clark?

Answer: The decision to request the resignations of Dr. Langenberg and Dr. Clark was my decision, based on my desire to make my own management team.

Question: Why did you ask of these individuals to resign?

Answer: As the new Director of the Foundation, I wished to have an opportunity to form my own top management team. This, I believe, will strengthen my ability to provide the leadership the Foundation requires in facing the challenges and opportunities of the 1980's.

Question: Dr. Knapp, do you believe that the manner in which these personnel decisions were made and announced will hurt your chances of finding highly qualified candidates who will accept the vacant posts?

Answer: I have absolutely no reason to believe that my decisions will affect my chances of finding highly qualified candidates for these positions.

Question: Dr. Knapp, will candidates for the vacant positions have to pass a political litmus test to be seriously considered for the jobs?

Answer: I have worked very closely with the National Science Board to develop a list of candidates for these positions. In developing these lists, our major criteria have been the demonstrated leadership, scientific, and managerial potential of the many candidates we have considered for inclusion. I believe that the final lists will provide the President a wide range of excellent choices.

Question: Dr. Knapp, can you give me some idea of when you will fill the vacancies created at NSF by your decisions?

Answer: The White House has had lists of potential candidates for almost three months now, and is working on the selection actively.

Question: Dr. Knapp, do you believe it is unusual for management changes at the NSF to occur so suddenly with the political appointment of a new director?

Answer: While it may be slightly unusual for management changes at NSF to occur so quickly after the appointment of a new Director, such changes are certainly not unprecedented.

Question: Dr. Knapp, in the December 8, 1982, New York Times, you are quoted as suggesting that the NSF would build social science research by emphasizing "The non-political aspects." What do you mean by "non-political?"

Answer: Perhaps I should have chosen a different term than "non-political" to express my views. I believe that our support of the social sciences is based, and must continue to be based, solely on judgments of scientific merit and opportunity. The peer review process and the general openness with which our support and funding decisions are made and reviewed in the social sciences are and remain our best guarantee that judgments will continue to be based on these criteria.

Science Education

Statement: Dr. Knapp, many of us here in Congress are very concerned by the low levels of achievement of our nation's students in math and science. S.A.T. scores in math have been declining for many years. The most recent national assessment of student achievement revealed that a great many students cannot perform anything more than simple one step mathematics computations -- and that almost 20% could not even do that. Their science knowledge was also woefully inadequate.

For these reasons, I intend to introduce legislation next week to address some of these problems. My legislation anticipates a role for NSF.

This administration has committed only $39 million in the NSF budget for Science and Engineering Education -- $19 million for graduate research fellowships and $20 million for pre-college teacher improvement in science and mathematics. The former program is designed to produce specialists in these fields, the latter to improve the status and training of existing teachers.

Question: Do you really believe that the problem in this area lies just with the inadequate training of existing teachers?

Answer: No, the problem is varied and has no simple solution. We hope to address a variety of problem areas with the funds appropriated by Congress for FY 1984, including pre-college teacher improvement.

Question: Since your budget will commit a small amount of resources that will benefit a small portion of the population, what will happen to the general population which has very large needs?

Answer: I believe that we can use our small resources with very high leverage to try to address a large portion of the population, not just the select few who will be scientists. General scientific literacy is a goal to which we are committed. Our entire population needs to be better informed about science and technology.

Question: A number of observers have stated that a significant teacher shortage currently exists in secondary schools among math and science teachers. Many schools are also operating with inadequate instructional equipment and materials. Does NSF have any programs to address these problems or are you contemplating establishing any? Do you believe that NSF should establish such programs?

Answer: The Foundation does not have such programs. Traditionally it has been the responsibility of the Department of Education to build general school capacity and provide large-scale, national support for instructional equipment and materials. In the past the NSF role has been limited to supporting the development of some instructional materials in science and math. We will be involved in such activities on a selected basis in the future. We will do so only when our efforts can be focused, can promise a high leverage on the much larger educational system, and can build on our distinctive relationship with the academic science community.

Question: I notice that your pre-college teacher improvement program focuses exclusively on math and science teachers at the secondary school level. However, a majority of the elementary school teachers in this country have little or no training in math and science. Moreover, a number of studies have discovered that student interest in math and science begins to decline

significantly in the third and fourth grades. Shouldn't the Federal government focus on elementary teachers also?

Answer: I would agree that the Federal government needs to focus on elementary teachers. The Department of Education has generally assumed responsibility for grades K through 4. It is true that student interest in math begins to decline in the third and fourth grades, but one would have to say there is very little science taught up to this point. This is a period of emphasis on mathematics and reading. The role of teacher training in that decline in interest is unclear. The evidence suggests that other factors, e.g., family orientations and support and peer group pressures, may be of greater significance to the decline in interest in math. We will accept proposals for elementary school science materials development.

Question: Where will the future specialists come from if elementary education remains inadequate?

Answer: The real point of no return is generally thought to be in the junior high school. Up until that time, problems can be remedied. The most important aspect of our education system is to be open and flexible, so that students can reenter.

EPA

Statement: Dr. Knapp, the President's FY 1984 budget proposal for the Environmental Protection Agency includes a transfer to the NSF of $4 million to carry out the EPA exploratory research program.

Questions: What type of research will these funds be used for? Who at EPA will oversee this program? Can you tell us what relationship this program has to the super fund?

Answer: It is the Foundation's understanding that the administration is no longer proposing that this transfer be made.

Question: Can you tell us of other interagency agreements that the NSF has?

Answer: In a typical year, NSF will enter into from 150 to 200 interagency agreements with over 20 other agencies. Total dollar amounts average approximately $20 million. NASA, Department of Energy, Department of Commerce (NOAA), Department of Interior (Geological Survey) and the Department of Defense account for over 90% of the total dollars. The agreements are for support of research projects, facilities support at the National Research Centers and for joint support of conferences and workshops.

Responses of Dr. Edward Knapp to Questions Submitted by Sen. Dodd

Statement: It is my understanding that reductions in funding in the International Cooperative Scientific Activities will be compensated by allotting additional monies to other NSF Directorates for international research projects. Does this mean that the program directors of the individual directorates have the responsibility of ensuring grant awards of $5.9 million to international scientific proposals?

Questions: If not, what person or office will be so responsible?

What guarantee can the NSF give that these international scientific projects will continue to be supported?

Answer: There will be no reductions in funding International Cooperative Scientific Activities, merely a shifting of responsibility to ensure both that the quality of science research supported is of the highest quality possible and that a holistic approach is taken by program managers in their support of projects. STIA personnel will coordinate these international cooperative programs and provide accounting support across the Foundation as required.

Question: Since there are no line items in the NSF budget proposal listed in the individual directorates, what kind of oversight provisions are provided under the Administration's proposal to monitor the transfer of funds?

Answer: A steering group has been appointed by the Director to work out the details of this management shift. One of its major responsibilities will be to establish a tracking system to track proposal by proposal and directorate by directorate, expenditures for international science. In addition they are to recommend the oversight responsibilities necessary to insure that NSF meets its international commitments in accordance with the existing bilateral agreements.

Statement: In the Special Foreign Currency program activity summary, there is listed a 16% reduction in funding for support of research activities in India and Pakistan.

Question: What is the justification for this reduction in funding?

Answer: If you look at the Foundation's Special Foreign Currency request for FY 1983, which was $2.2 million, and the FY 1984 Request of $2.6 million you observe a requested increase of $0.4 million rather than a decrease. The apparent decrease occurs because of a $918,067 carryover of FY 1982 funds.

Question: How will the special projects, such as geology, chemistry, atmospheric sciences, engineering, etc., supported under this program be affected by these reductions in funding?

Answer: The special programs will continue to be supported as strongly as before since there has been no rduction in our Special Foreign Currency request.

The CHAIRMAN. Our next witness will be Dr. James J. Brophy, who is vice president for research at the University of Utah in Salt Lake City, Utah.

Dr. Brophy is going to discuss with us basic research and the National Science Foundation.

Dr. Brophy, we are really happy to have you with us. Inasmuch as you are from my home State, we appreciate all of the leadership that we are getting in this area from the University of Utah, and in particular the medical school. We are looking forward to taking your testimony at this time.

STATEMENT OF DR. JAMES J. BROPHY, VICE PRESIDENT FOR RESEARCH, UNIVERSITY OF UTAH, SALT LAKE CITY, UTAH

Dr. BROPHY. Thank you, Senator.

Mr. Chairman, I am James Brophy, vice president for research at the University of Utah. I am most pleased to have this opportunity to comment on basic research and the National Science Foundation.

I can best epitomize my remarks through some anecdotal activities surrounding a recent event of some scientific note. My story is the debt that the artificial heart in Dr. Barney Clark owes to the basic research supported by the National Science Foundation beginning more than 10 years ago.

The specific story revolves around Dr. Donald V. Lyman, professor of materials science and engineering and research associate professor of surgery at the University of Utah and his deep interest in the fundamental interactions between blood and solid organic materials known as polymers.

One of the major difficulties associated with the introduction of foreign material next to living cells is the reaction of these cells to the invader substance. Dr. Lyman resolved to study one of the more difficult and sensitive of these reactions; that is the tendency of blood to clot at the surface of such materials.

In 1971 the National Science Foundation program in materials science responded to a proposal from Dr. Lyman to study the mechanisms of blood polymer interaction with a 3-year grant totaling $263,000. Don, who is a polymer chemist, proposed to explore the influence of the chemical and physical structure of polymers upon these mechanisms in order to develop an understanding of the fundamental processes involved.

As a result of the understanding he has achieved, it is now possible to design both the chemical structure and the proper fabrication processes to produce blood-compatible materials. And, although the goals of his program with NSF did not include the application to medical devices, an early successful artificial heart model employed a smooth polyurethane polymer at Dr. Lyman's suggestion. Indeed, similar materials are currently used in Dr. Clark's heart.

I do not want to make this an exposition on artificial hearts, Senator, but because of the interest, I thought it might be useful to bring along a model of the heart to show it to the committee. This is a polyurethane heart. It is identical to the one that beats in Dr. Clark's chest.

Very briefly, it consists of two parts, a left ventricle and a right ventricle, which are fastened together. The heart is driven pneumatically by compressed air.

To show you better how that works, let me show you this cutaway model, which shows how the diaphragm is driven back and forth to pump the blood in and out of the two sides of the heart.

Let me show you so that the committee can examine it.

[Dr. Brophy shows artificial heart to Senator Hatch, Senator Pell, and the committee staff.]

The CHAIRMAN. We ought to have one of those as a permanent exhibit here at the committee. I know a few on the committee who may need an implantation at sometime or another. [Laughter.]

Dr. BROPHY. Senator, as a matter of fact, I notice that Dr. L'Enfant brought the model of the Utah heart to the NIH hearings yesterday, which moves me to remark that of all the people approaching this committee figuratively, you have now seen two people approach it literally with our hearts in our hands. [Laughter.]

The NSF also supported other investigators at the University of Utah and at other institutions who have contributed in diverse ways. I should note that this was not a directed development program, but rather a confluence of many separate investigations brought together into one milestone achievement. It is also safe to say that these many studies will contribute equally to other advances yet to come.

For example, an NSF research instrumentation grant in the mid-1970's helped the University of Utah to acquire a scanning electron microscope in order to enhance our basic research efforts in ceramics. That instrument was used to examine the surfaces of all specimens from artificial heart animal experiments.

Last year we received a $250,000 NSF grant as partial support for a more advanced instrument, a scanning transmission electron microscope. Although this sophisticated instrument is intended for studies on composite materials, structural materials, it, too, will contribute directly to our continuing research on body-compatible materials.

I would be remiss if I did not take note that the bulk of artificial heart research has been supported by the National Institutes of Health, and properly so. It is important to note, however, the useful and synergistic research programs of NSF and NIH, and the fact that they were mutually interactive to this happy result.

Similarly, I should record the names of Drs. Willem Kolff, Robert Jarvik, Donald Olsen, William De Vries, Lyle Joyce, and others who were directly involved with artificial heart research for many years.

As a matter of fact, Dr. Lyman's more applied research interests are not to artificial hearts at all. The polymers developed through his NSF program results are particularly useful for artificial blood vessels. Last year he received Federal Food and Drug Administration approval for clinical studies, and he anticipates initial human implantation next month. This application, though somewhat less dramatic than the artificial heart, will benefit the much larger group of people who suffer from blood vessel breakdowns.

I do have two short sections of artificial blood vessels produced by Dr. Lyman. This one is about a centimeter in diameter.

The CHAIRMAN. That is a polymer material?

Dr. BROPHY. This is polymer material.

Here is one for one of the large arteries near the heart.

[Dr. Brophy shows two artificial blood vessels.]

Though clinical studies are not supported by the National Science Foundation, and again properly so, and again demonstrating the synergism between NSF and NIH programs, Dr. Lyman's research has been funded by NSF for more than a decade. During this period he has directed 4 Ph. D. students, 10 master's candidates, 8 postdoctoral appointees, and some 7 surgical residents.

Clearly, the educational mission of the National Science Foundation and the University of Utah has been well served by this research effort.

Incidentally, Dr. Lyman now has some anxiety over the fact that in the light of quite proper agency concern over funding for young investigators, his research support may tend to diminish. This is the difficult balance which NSF and other basic research agencies must continually address.

Finally, let me note that these events have also achieved another NSF goal, and in this instance without direct NSF support. Both artificial hearts and artificial blood vessels are to be produced by private, high-technology companies created specifically to make these advances readily available to the benefit of the public. This is, I believe, a classic example of Federal-agency research, university-private-sector cooperation to the public good through science and technology.

What do we learn from this story? That basic research is good? I suspect you already know that, and I apologize if I appear to have wasted your time. It seems to me, however, that we do need to be reminded of the origins of such successes as the artificial heart and artificial blood vessels in order to sustain our faith and belief in basic research. I sincerely hope that I have been able to do that for you in these few minutes and from my perspective.

In your deliberations concerning the NSF program and budget, and in full awareness of the difficult compromises and decisions you face, I respectfully urge you to sustain the basic research capacity of the National Science Foundation so that we may experience together the satisfaction of more Barney Clark excitements in the future.

Thank you for your kind attention, Senator.

The CHAIRMAN. Thank you, Dr. Brophy.

[The prepared statement of Dr. Brophy follows:]

BASIC RESEARCH AND THE NATIONAL SCIENCE FOUNDATION

A STATEMENT BY

JAMES J. BROPHY
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SALT LAKE CITY, UTAH 84112

MARCH 18, 1983

Mr. Chairman and members of the committee, I am James Brophy, Vice President for Research at the University of Utah, and I am most pleased to have this opportunity to comment on basic research and the National Science Foundation. I believe that I can best epitomize my remarks through some anticdotal activities surrounding a recent event of some scientific note. My story is the debt that the artifical heart in Dr. Barney Clark owes to basic research supported by the National Science Foundation beginning more than 10 years ago.

The story revolves around Dr. Donald V. Lyman, Professor of Materials Science and Engineering and Research Associate Professor of Surgery at the University of Utah and his deep interest in the fundamental interactions between blood and solid organic materials known as polymers. One of the major difficulties associated with the introduction of foreign material next to living cells is the reaction of these cells to the invader substance. Dr. Lyman resolved to study one of the more difficult and sensitive of these reactions; that

is the tendency of blood to clot at the surface of such materials.

In 1971 the National Science Foundation responded to a proposal from Dr. Lyman to study the mechanisms of blood polymer interaction with a three-year grant totalling $263,000. Don proposed to explore the influence of the chemical and physical structure of polymers upon these mechanisms in order to develop an understanding of the fundamental processes involved. As a result of the understanding he has achieved, it is now possible to design both the chemical structure and the proper fabrication processes to produce blood compatible materials. And, although the goals of his program did not include application to medical devices, an early successful artificial heart model employed a smooth polyurethane polymer at Dr. Lyman's suggestion. Indeed, similar materials are currently used in Dr. Clark's heart.

NSF also supported other investigators at the University of Utah and at other institutions who have contributed in diverse ways. Note that this was not a directed development program, but rather a confluence of many separate investigations brought together into one milestone achievement. It is also safe to say that these many studies will contribute equally to other advances yet to come.

For example, a NSF research instrumentation grant in the mid 1970's helped the University of Utah to acquire a

scanning electron microscope in order to enhance our basic research efforts in ceramics. That instrument was used to examine the surfaces of all specimens from artifical heart animal experiments. Last year we received a $250,000 NSF grant as partial support for a more advanced instrument, a scanning transmission electron microscope. Although this sophisticated instrument is intended for studies on composite materials, it, too, will contribute directly to our continuing research on body-combatible materials.

I would be remiss if I did not take note that the bulk of artificial heart research has been supported by the National Institutes of Health, and properly so. It is important to note the useful and synergistic research programs of NSF and NIH and the fact that they were mutually interactive to this happy result. Similarly, I should record the names of Drs. Willem Kolff, Robert Jarvik, Donald Olsen, William De Vries, Lyle Joyce and others who were directly involved with artificial heart research for many years.

As a matter of fact, Dr. Lyman's more applied research interests are not to artificial hearts at all. The polymers developed through his NSF program results are particularly useful for artificial blood vessels. Last year he received Federal Drug Administration approval for clinical studies and he anticipates initial human implantation next month. This application, though somewhat less dramatic than the

artificial heart, will benefit the much larger group of people who suffer blood vessel breakdown.

Though such clinical studies are not supported by NSF (and again demonstrate the synergism of NSF and NIH programs), Dr. Lyman's research has been funded by NSF for more than a decade. During this period he has directed four PhD students, 10 MS candidates, eight Post Doctoral appointees, and some 7 surgical residents. Clearly, the educational mission of NSF and the University of Utah has been well served by this research effort. Incidentally, Dr. Lyman now has some anxiety over the fact that in the light of quite proper concern over funding for young investigators, his research support may tend to diminish. This is the difficult balance which NSF and other basic research agencies must continually address.

Finally, let me note that these events have also achieved another NSF goal, and in this instance without direct NSF support. Both artificial hearts and artificial blood vessels are to be produced by private, high technology companies created to make these advances readily available to the benefit of the public. This is, I believe a classic example of federal agency/research university/private sector cooperation to the public good through science and technology.

What do we learn from this story? That basic research is good? I suspect you already know that and I apologize

if I appear to have wasted your time. It seems to me, however, that we do need to be made aware of the origins of such successes as the artificial heart and artificial blood vessels in order to sustain our faith and belief in basic research. I sincerely hope that I have been able to do that for you in these few minutes and from my perspective.

In your deliberations concerning the NSF program and budget, and in full awareness of the difficult compromises and decisions you face, I respectfully urge you to sustain the basic research capacity of NSF so that we may experience the satisfaction of more Barney Clark excitements in the future.

Thank you for your kind attention.

The CHAIRMAN. I have to confess that I think the successes that the University of Utah has had, especially in this implantation of the artificial heart, have been noticed by people all over the world. Perhaps we need to get more money out there for basic research. We will see what we can do.

Let me just ask you a couple of questions about the various programs at the University of Utah, in particular, the artificial organ program directed by Dr. Kolff and others, and any other programs you would care to tell us about in basic and applied research.

Dr. BROPHY. Senator, if you are asking me to tell you what the University of Utah is good at, I could spend the rest of the afternoon. I know you do not wish that.

Let me say this: We do have the largest groundbased cosmic ray program in the country, perhaps in the world. It is supported by the National Science Foundation. We have an outstanding program in human genetics, which will contribute, as we heard yesterday in NIH testimony, to the prevention of disease rather than the cure of disease through an understanding of the genetic origins of disease.

We have a major program in computer sciences. We received a major grant from the National Science Foundation in computer sciences last year.

Let me just close by saying our programs in chemistry and computer science and mathematics are rated in the top teens to twenties—they have been rated in terms of our graduate programs in these sciences by a national study completed a few months ago.

The CHAIRMAN. I want to compliment the University of Utah, you and others, because the programs that you have run have been cost-effective. I think they have been very efficient, and of course I think you have broken through in a number of areas to benefit not only our great country, but also all of mankind.

We appreciate what you are doing. It is good to have you here demonstrating the artificial heart and the artificial blood vessels and the special uses of polymers, which were mentioned yesterday by Dr. Chase Peterson from the University of Utah with regard to the National Institutes of Health funding. These are historic achievements. To have these innovations before us today, I think, is a real tribute to you and certainly a blessing to the committee.

I would like to recess for just a few minutes. I have to chat with the Attorney General of the United States. Dr. Brophy, I would like you to take some time, if you will, to show these organs to the people who are here in attendance and just tell them a little bit about them. I will be right back in a couple minutes after this phone call.

Dr. BROPHY. Sure.

The CHAIRMAN. We will recess for a couple minutes.

[Recess taken.]

The CHAIRMAN. We will now call this committee back to order.

Our third witness today will be Dr. Elinor Ostrom, chairperson of the Department of Political Science, Indiana University, Bloomington, Ind.

Dr. Ostrom will be speaking on the social and behavioral science programs of the National Science Foundation.

Dr. Ostrom, we are very delighted to have you with us today.

STATEMENT OF DR. ELINOR OSTROM, CHAIRPERSON OF THE DEPARTMENT OF POLITICAL SCIENCE, INDIANA UNIVERSITY, BLOOMINGTON, IND.

Dr. OSTROM. Senator Hatch, members of the Committee on Labor and Human Resources, my name is Elinor Ostrom. I am chairperson of the Department of Political Science at Indiana University.

I am testifying today on behalf of the Consortium of Social Science Associations, COSSA, which represents more than 150,000 social scientists across the country.

I wish to make my written statement a part of your record and provide an overview of that statement with some further examples.

I appreciate the opportunity to testify before this committee on the fiscal year 1984 budget of the National Science Foundation. Last year your committee voted to add $5 million to the National Science Foundation budget with those funds designated to go to the social and behavioral science research program. Social and behavioral scientists across this country appreciate the level of your support.

This year, as you know, the administration is requesting an increase of almost 18 percent for its budget for the National Science Foundation. The administration concurs with your judgment last year in that it is requesting, for the first time in 2 years, an increase in the social and behavioral sciences budget. That is the good news.

The bad news is that the increase requested for the social and behavioral science programs in fiscal year 1984 is considerably less than that requested for the physical and natural sciences and that the very heavy budget cuts imposed in fiscal years 1981 and 1982 have still not been restored.

My own view, and that of the Consortium of Social Science Associations, is that the administration's emphasis on R&D expenditures in its fiscal year 1984 budget request is wise. George A. Keyworth II, the President's Science Advisor, has repeatedly said that the fiscal year 1984 budget figures are intended to reflect the importance the administration attaches to the role of R&D in dealing with current economic conditions. The fiscal year 1984 budget for R&D is intended to stimulate both the technological innovations and economic development that will lead to sustained economic recovery. I endorse this.

However, I cannot see sustained economic recovery emerging from a policy that defines research and development so narrowly as to exclude the level of support for the social and behavioral sciences that is necessary under current conditions.

To repeat, COSSA supports the large increases in the NSF budgets for math, physical sciences, engineering, and the biological sciences. But if the purpose of the NSF increase is to stimulate technological innovations and economic development, there must be a considerably larger than presently scheduled increase in the budgets of the social and behavioral science programs. Technological innovation and the economy are both objects of social science research.

The introduction and success of new technologies may be as much dependent upon organizational and behavioral research as

they are on technological factors. Future use of new technologies will be as constrained by workers' skills, mobility, and adaptability—all studied by social and behavioral sciences—as by the availability of investment capital and technological innovation. There is no technological quick-fix.

Focusing primarily on hardware types of technology only raises false expectations when sufficient investment is missing in regard to research on human factors that make a technology successful.

If, then, the administration's science policy and its research budgets are directed toward national needs, they must attend to the social and behavioral sciences at least as much as to the physical and natural sciences. Thus, the 1984 budget request for the National Science Foundation falls short of its purposes.

Let me turn to two points today:

One, the cumulative effects of past cuts in the NSF social and behavioral science programs have hindered further development in these areas.

Two, there are many cases of scientific opportunity in the social and behavioral sciences that cannot be explored because of current low levels of funding.

First, fiscal year 1984 budget request for an increase of 12.5 percent in the social and behavioral science research programs is welcome. Our pleasure at that increase should not, however, obscure the fact that the social and behavioral sciences continue to receive a declining proportion of National Science Foundation research funds. In 1980 the social and behavioral science programs received 5.9 percent of all of these funds. By 1983 it was only 3.4 percent. In fiscal year 1984, despite the increases, we will be down to only 3.3 percent of the research funds made available to the National Science Foundation.

The hidden costs of these effective budget cuts are great. First, there is the cost in new students who are discouraged from entering. We are sending a signal that social and behavioral sciences are not where the action is in the future. However, it is not only the students who are being discouraged by the decline in funding. Another effect of the budget cut is that professional social and behavioral scientists realize that large, ambitious, and frequently innovative research projects have little chance of being funded.

Now we see many safe, solid, and small projects. Small projects provide some of the necessary building blocks in any science. My criticism, however, lies in the fact that when small projects become dominant, a science moves slowly.

Social and behavioral science disciplines now require large and continuing longitudinal data sets, computer facilities, and support for experiments in a variety of areas. At the University of Michigan, for example, computer use by social and behavioral scientists is at least as large as their representation among the faculty at the University of Michigan.

Another effect of the budget cuts is that funds are now being made available for large-scale data bases, but not necessarily for the development of measures which must precede data collection or for the analysis of data once it is collected.

While social and behavioral scientists face different instrumentation needs than physical scientists, this does not mean that they are less expensive or less central. They are different.

Many national policies are dependent on the development of accurate data about key phenomenon. For example, we are now concerned about the crises of the big cities or the crises of the cities generally. There are no really accurate data sets that provide valid information about comparative city expenditures for different items. Every city in this Nation uses a different form for accounting. The census of Government data does not provide anything but a rough idea of valid expenditure levels.

The same is true for crime data. The FBI crime index is only the roughest of approximations.

No physical scientist would work with data as error filled as the social scientist must frequently make use of. For all too long, social scientists have been expected to produce quick and dirty analyses upon which major social and organizational policies are based. It is in the interest of this Congress to improve support for the social and behavioral scientists, so that future public policies are based on a more accurate understanding of key social processes occurring in this country.

The second topic I wish to address is current research opportunities in the social and behavioral sciences that are being missed.

I have neither the time nor the space to explore the full range. It is clear that the social and behavioral sciences are central to those policy areas which are most pressing in the United States today.

For example, we have learned in recent years that as much as 50 percent of our medical problems have social and behavioral components; that social statistics are used in the allocation of about one-fifth of the Federal budget; that human factors are critical in the introduction and maintenance of advanced technologies, including disasters such as that which occurred at Three-Mile Island. Without basic support for basic research, U.S. policies in this area will be defined as much by past prejudice as by understanding and knowledge.

Because of time constraints, I can only talk about three areas of research that could be done at current resource levels.

The first deals with the behavior of bureaucracies. Recent work on mathematical models for allocated institutions has proved useful in understanding the behavior of market institutions. This is an important area about which President Reagan said, "One of the challenges facing all of us . . . (is to understand) the marketplace, how it functions, and what is required to make it work."

These models can also be applied to the study of bureaucracies and political organizations and can help us to understand what contributes to the efficiency and inefficiency of bureaucratic organization. However, we are prevented from expanding research in this area by limitations on our analytic technologies. To develop those analytic technologies sufficiently we need sustained research support, both to accomplish the methodological research and to attract able, young scientists into the field.

A second area that cannot be developed to the extent that it is needed is the question of how to improve the productivity of State and local governments where more and more pressure is being

placed for doing more for less. Basic research is needed on a number of fronts. One important area is the conception of the production process itself. Recently theoretical work has shown that we should conceptualize many human service delivery processes as coproduction processes. Schools do not produce education alone. Police do not produce safety from crime alone. These are basically processes coproduced by citizens and families working with public officials.

Almost all of our theoretical models focus on the role of the Government sector and public officials when we model the test data about local government efficiency. With the new theoretical work, we need new data collection and new types of data sets in order, then, to test how do we enhance the coproduction of citizens as well as local officials in solving problems of the big cities.

The third area of opportunity is the field experiments in legal innovations. One potentially profitable area is divorce mediation. Many feel that mediation is cheaper and more satisfactory than court actions in divorce settlements. Social scientists could be involved in research on this subject as it develops, designing and testing programs that might improve the process and further lower the cost.

These are only three suggestions for new research that can be undertaken right now. There are many other examples which I could also describe, if time were not limited.

For example, additional research could be done on the subject of savings behavior using microlevel data. This would have implications for our knowledge of capital formation in the economy, financial security after retirement, and the distribution and intergenerational transmission of wealth.

Another subject is the effects of divorce on men, women, and children, using longitudinal survey data that would permit us to examine effects on the same individuals over time.

Still another important area is regional development and stagnation. Research could examine the nature of the diffusion of industrial innovations by multinational, multiregional, and single-plant firms. This has obvious implications for the future development of regions of the United States that are currently in economic decline because of changes in the profitability of certain kinds of industry. There are many more studies of this kind, but they will not be done at current levels of support.

In conclusion, I would urge the committee to increase the authorization for the social and behavioral science programs at the National Science Foundation, not only because the original cuts were without scientific foundation; not only because they have potentially harmful long-range effects if they are allowed to stand; but because the research agenda in the social and behavioral sciences is too important to the Nation to allow these programs to wither.

Thank you.

The CHAIRMAN. Thank you, Dr. Ostrom.

[The prepared statement of Dr. Ostrom follows:]

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STATEMENT OF DR. ELINOR OSTROM

Chairperson, Department of Political Science
Indiana University

on the

SOCIAL AND BEHAVIORAL SCIENCE PROGRAMS

OF THE NATIONAL SCIENCE FOUNDATION

PREPARED FOR THE

SENATE COMMITTEE ON LABOR AND HUMAN RESOURCES

The Honorable Orrin G. Hatch, Chairman

March 18, 1983

Senator Hatch, Members of the Committee on Labor and Human Resources: My name is Elinor Ostrom, and I am chairperson of the Department of Political Science at Indiana University. I am testifying today on behalf of the Consortium of Social Science Associations (COSSA), which represents approximately 150,000 social and behavioral scientists in the United States. A list of COSSA Members, Affiliates, and Contributors is given at the end of my testimony.

I appreciate the opportunity to testify before this Committee on the FY 1984 budget of the National Science Foundation (NSF). Last year the Committee on Labor and Human Resources voted to add $5 million to the NSF research budget and specifically earmarked those funds for the social and behavioral science research programs. Social and behavioral scientists appreciate the Committee's support.

This year, as you know, the Administration is requesting an increase of almost 18% over its FY 1983 budget for NSF. It is significant, I believe, that the Administration concurs with this Committee's judgment last year in that it is requesting, for the first time in two years, an increase in the budgets of the social and behavioral science research programs as well as increases in the physical and natural sciences. That is the good news. The bad news is that the increase requested for the social and behavioral science programs in FY 1984 is considerably less than that requested for the physical and natural sciences and that the very heavy budget cuts imposed in FY 1981 and FY 1982 have not been restored. (See attached table.)

My own view, and that of the Consortium of Social Science Associations, is that the Administration's emphasis on research and development (R&D) expenditures in its FY 1984 budget request is both wise and appropriate. George A. Keyworth II, the President's Science Advisor, has repeatedly said that the FY 1984 budget figures are intended to reflect the importance that the administration attaches to the role of R & D in dealing with the current economic situation. The FY 1984 budget for R & D is intended to stimulate both technological innovations and economic development that will lead to sustained economic recovery. I fully endorse Dr. Keyworth's intention. I differ with him, however, in that I cannot see sustained economic recovery emerging from a policy that defines research and development so narrowly as to exclude the level of support for the social and behavioral sciences that is necessary under current conditions.

To repeat, the Consortium of Social Science Associations supports the large increases in the NSF budgets for math and the physical sciences, engineering, and the biological sciences. But if the purpose of the NSF increase for FY 1984 is to stimulate technological innovations and economic development, there must be a considerably larger increase in the budgets of the social and behavioral science programs than is presently scheduled. Both technological innovation and the economy are the objects of social and behavioral science research. Productivity, for example, is as much a behavioral as a technological problem; and the introduction of new technologies is as dependent upon social, organizational,

and behavioral factors as it is on technical factors. Moreover, future use of new technologies will be as constrained by workers' skills, mobility, and adaptability -- all studied by social and behavioral scientists -- as by the availability of investment capital and technological innovations. In short, there is no technological quick-fix that will solve our problems.

Going beyond immediate questions of technology and the economy, we must also admit that the United States faces growing problems associated with unemployment, aging, family instability and change, sickness and health, and individual and family need -- none of which will be assisted in any way by major investments in math and the physical sciences.

If, then, the Administration's science policy and its research budgets are directed toward national needs, they must attend to the social and behavioral sciences at least as much as to the physical and natural sciences. For this reason, the FY 1984 budget request for the National Science Foundation falls short of its purpose.

I would like to address two points today:

1) The cummulative effects of the budget cuts in the NSF social and behavioral science programs in FY 1981 and FY 1982 are hindering both the development of the scientific disciplines and the ability of the social and behavioral sciences to address the needs described above;

2) there are at present many areas of scientific opportunity in the social and behavioral sciences that cannot be explored because of current low levels of funding.

(1) THE EFFECT OF THE FY 1981 - 1982 BUDGET CUTS

The FY 1984 budget request for an increase of 12.5 percent in the social and behavioral science research programs is welcome. Our pleasure at the increase should not, however, obscure the fact that the social and behavioral sciences continue to receive a declining proportion of NSF funds devoted to Research and Related Activities. In FY 1980, the social and behavioral science programs received 5.9% of all the funds in Research and Related Activities. By FY 1983, it was only 3.4%. In FY 1984, despite the requested 12.5% increase, the social and behavioral science programs at the Foundation will receive even less -- only 3.3% of research funds.

The hidden costs of these budget cuts have been great. First, there is the cost in new students who are discouraged from entering the social and behavioral sciences. The federal budget cuts send a message to students that these sciences are less important than others and that there will be little future in these fields. This has the effect of discouraging all students, but in particular, it discourages the better students who can find more support and, by implication, more profitable careers in other fields. Today, for example, the Division of Social and Economic Sciences in NSF supports fewer than 60% of the graduate students supported under research grants six years ago.

It is not only the students who are being discouraged by the decline in funding. Another effect of the budget cuts is that professional social and behavioral scientists realize that the

large, ambitious, and frequently most innovative research projects have little chance of being funded out of research budgets subject to the cuts the size of those imposed at NSF. The alternative, in too many cases, is the safe, solid, and small project. I do not criticize small projects; they provide the necessary building blocks of any science. My criticism, however, lies in the fact that when small projects begin to dominate, the science moves slowly. In this manner, the social and behavioral sciences are being held back from meeting the challenges that face them today.

Moreover, in many cases, it is too late for small projects in the social and behavioral sciences. The disciplines now require large and continuing longitudinal data sets, advanced computer facilities, and support for experiments in such diverse areas as market behavior and enforced mediation. At the University of Michigan, for example, computer use by social and behavioral scientists is roughly equal to the representation of these disciplines among all scientists and engineers at the university. In short, the social and behavioral sciences share the instrumentation needs of the other sciences.

A third effect of the budget cuts is that funds are now being made available for large scale data bases, but not necessarily for the development of measures that must precede data collection nor for the analysis of the data subsequent to its collection.

Finally, many research projects cannot be accomodated at all under current levels of funding. In most cases, moreover, there is no private sector source of research support to replace the federal government's investment in research.

(2) SCIENTIFIC OPPORTUNITIES

The second topic I wish to address is current research opportunities in the social and behavioral sciences.

I have neither time nor space to explore the many new areas of research in the social and behavioral sciences that we are capable of entering but lack the research support necessary to explore. The difficulty is due in part to the broadness of the social and behavioral science disciplines and in part to the number of research areas that currently offer important research opportunities.

It is clear, moreover, that the social and behavioral sciences are central to those policy areas which are most pressing in the United States today. For example, we have learned in recent years that as much as 50% of our medical problems have social and behavioral components; that social statistics are used in the allocation of approximately one-fifth of the federal budget; that human factors are critical in the introduction and maintenance of advanced technologies -- and in avoiding future catastrophes such as that at Three Mile Island; that significant developmental changes take place over the entire life course, that we are not irrevocably bound by our early experiences, and that we continue to learn at all ages (this has obvious implications for reemployment and retraining programs); and much more. Without adequate support for basic research, U.S. policies in these areas will be defined as much by past experience and prejudice as by understanding and knowledge.

Today, because of time constraints, I will discuss only two areas of research that cannot be done at current resource levels. One deals with understanding the behavior of bureaucracies and political institutions, one with field experiments in legal mediation.

Recent work on the development of mathematical models for allocative institutions has proven useful in understanding the behavior of market institutions. This is an important area about which President Reagan said "one of the challenges facing all of us...[is to understand] the market place, how it functions, and what is required to make it work" (Washington Post, January 31, 1983). These models can also be applied to the study of bureaucracies and political organizations and can help us to understand what contributes to efficiency and inefficiency in bureaucratic organizations. But we are currently prevented from expanding work in this area by the limitations of our analytic technologies. To develop these analytic technologies sufficiently to apply the models to bureaucracies, we need sustained research support both to accomplish the methodological research and to attract able young scientists into the field. Here, as in many research areas on the scientific frontiers, the need is for both research support and scientific personnel.

A second area of opportunity is field experiments in legal innovations. One potentially profitable area is divorce mediation. Many feel that mediation is cheaper and more satisfactory than court actions in divorce settlements. Social scientists could be involved in research on this subject as it develops, designing and testing programs that might improve the

process and further lower its cost. For example, one could design an experiment in which some people were required to attempt mediation, some were allowed to do so, and some did not have the option. Ideally, the experiment would vary styles of mediation and would vary subject matter, since there may be complicated and non-obvious interactions between the compulsory character of mediation, the subject matter of the mediation, and the procedures used. Several replications of such a study, which would be needed to ensure reliability, could easily run into seven figures, but it might yield dividends of tens or even hundreds of times this amount in terms of unclogged courts and increased litigant satisfaction. On the other hand, such research might reveal that the promise of mediation was sometimes or often illusory. In this case, we would be cautioned against spending the millions of dollars that we as a society now appear likely to put into such efforts.

These are only two suggestions for new research that can be undertaken right now. There are many other examples which I could also describe if time were no problem. For instance, additional research can be done on the subject of savings behavior using micro level data. This would have implications for our knowledge of capital formation in the economy, financial security after retirement, and the distribution and intergenerational transmission of wealth. Another subject is the effects of divorce on men, women, and children, using longitudinal survey data that would permit us to examine effects on the same individuals over time. We could then look at, for example, the social and educational implications of divorce for children, the emotional

and career implications for men and women, and the effects of family divorce on future marriages. Still another important topic is regional development and stagnation. Research could examine the nature of the diffusion of industrial innovations by multinational, multiregional, and single-plant firms. This has obvious implications for the future development of regions of the United States that are currently in economic decline because of changes in the profitability of certain kinds of industry. There are many more studies of this kind, but they will not be done at current levels of support.

In conclusion, I would urge the Committee to increase the authorization for the social and behavioral science programs at the National Science Foundation -- not because the original cuts were without scientific foundation (though they were); not because they have potentially harmful long-range effects if they are allowed to stand (which they do); but because the research agenda in the social and behavioral sciences is too important to the nation to allow these programs to wither.

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NATIONAL SCIENCE FOUNDATION

Level of Funding for Selected Directorates and Programs
(in million $)

	Actual 1980	Actual 1983	Proposed 1984	%Change FY80-84	%Change FY83-84
Directorate for Mathematical and Physical Sciences (MPS)	$227.0	$299.7	$364.3	+60%	+22%
Directorate for Astronomic, Atmospheric Earth and Ocean Sciences (AAEO)	218.1	276.2	334.9	+54%	+21%
Directorate for Biological, Behavioral and Social Sciences (BBS)	185.7	190.2	223.6	+20%	+18%
Social and Behavioral Science Research Programs in BBS:					
Division of Behavioral & Neural Sciences					
Neuroscience Psychobiology	4.5	3.7	3.8	-16%	+3%
Cognitive Science					
Memory & Cognitive Processes	2.6	2.3	2.6	-	+13%
Social & Developmental Psychology	3.3	2.1	2.2	-33%	+5%
(Applied Psychology - absorbed elsewhere)	1.4	-	-		
Linguistics	2.7	2.2	2.4	-11%	+9%
Anthropology	6.6	5.8	6.3	-5%	+9%
Subtotal	21.1	16.1	17.3	-18%	+7%
Division of Social & Economic Science					
Economics and Geography					
Economics	12.2	7.1	9.1	-25%	+28%
Geography	1.6	0.8	1.0	-38%	+25%
Social Measurement & Analysis					
Sociology	3.9	2.4	2.8	-28%	+17%
Measurement Methods & Data Resources	5.0	3.3	3.5	-30%	+6%
History & Philosophy of Science	1.5	1.1	1.2	-20%	+14%*
Political & Policy Sciences					
Political Science	3.6	2.3	2.6	-28%	+12%*
Law & Social Sciences	0.9	1.2	1.3	+44%	+4%*
Regulation & Policy Analysis	2.6	0.9*	0.9*	-65%	+6%
Decision & Management Science		0.8	1.0		+25%
Subtotal	31.3	19.9	23.4	-25%	+18%
TOTAL - Social & Behavioral Science	52.4	36.0	40.7	-22%	+13%
Social & Behavioral Science as Proportion of Research and Related Activities	5.9%	3.4%	3.3%		

*Rounding artifact -- calculations from unrounded figures
All figures rounded to the nearest tenth of a million

Consortium of Social Science Associations

Members

American Anthropological Association
American Economic Association
American Historical Association
American Political Science Association
American Psychological Association
American Sociological Association
American Statistical Association
Association of American Geographers
Association of American Law Schools
Linguistic Society of America

Affiliates

American Association for Public Opinion Research
American Educational Research Association
Eastern Sociological Society
Economic History Association
Evaluation Research Society
History of Science Society
Law and Society Association
National Council on Family Relations
North Central Sociological Association
Northeastern Anthropological Association
Population Association of America
Regional Science Association
Social Science History Association
Society for American Archaeology
Society for Psychological Anthropology
Society for the Scientific Study of Religion
Society for Social Studies of Science
Southwestern Social Science Association

Contributors

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Georgia Institute of Technology
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Institute for Social Research, University of Michigan
University of Illinois
University of Iowa
University of Michigan
University of Missouri
University of Nebraska
University of Oregon
University of Pittsburgh
Princeton University
Social Science Research Council
University of Southern California
Stanford University
Texas A & M University
Tulane University

The CHAIRMAN. I have a rollcall vote on the floor. Therefore, I am going to submit questions to you and, of course, keep the record open for other members of the committee to submit appropriate questions to you.

We appreciate the testimony you have given today.

[Responses to questions asked follow:]

INDIANA UNIVERSITY

DEPARTMENT OF POLITICAL SCIENCE
Woodburn Hall
Bloomington, Indiana 47405

May 18, 1983

The Honorable Orrin G. Hatch
Chairman, Committee on Labor
and Human Resources
United States Senate
Washington, D.C. 20510

ATTENTION: Kris Iverson

Dear Senator Hatch:

Enclosed are my answers to the questions you sent me a month ago. Unfortunately, I have had very heavy obligations both on campus and at other institutions during the past month. Thus, I had to wait until the semester had ended before I could address your important questions. I hope the enclosed will be of use to you and members of the Committee.

I would be happy to answer further questions if you so desire and/or to send you relevant materials if needed.

Sincerely yours,

Elinor Ostrom

Elinor Ostrom
Chairperson

/tt

Enclosure

1. "Could you describe in a little more detail the process social scientists must follow before large-scale data bases can be used effectively?"

Many steps must be undertaken before a large-scale data base can be developed in the first place. First, one needs a careful conceptual definition of what is to be measured. For example, if one is interested in understanding some of effects of unemployment on crime, one needs a good conceptual definition of both unemployment and crime. While these terms are used frequently in everyday language and national indicators are produced, considerable problems exist with these indicators. National figures for unemployment, for example, are determined by counting those individuals who have continued to actively seek employment. If one is interested in gaining a better idea of both the amount of unemployment and its effects on crime, one needs to develop a very careful definition of unemployment that would the many individuals who have given up any hope of finding employment.

In regard to crime, we frequently use the FBI Crime Index in our everyday discussions of the amount of crime in the United States. However, the FBI Crime Index reports the frequency of seven particular crimes but does not report many frequently committed crimes of deep concern. Unemployment may lead to increases in bank fraud and other fraudulent practices, for example. One would not be able to ascertain this relationship using the FBI Crime Index as a measure of crime.

Having defined these two concepts more carefully and related them to the research question at hand, a researcher would then have to determine the best way of obtaining data about these concepts. In regard to unemployment, one would need to experiment with various kinds of data sources already collected and verified by random samples of population and/or diverse record checks. The researcher must determine what is the most efficient and effective way to get a valid and reliable indicator of unemployment if one who is to move away from strict reliance on the current figures that count only those persons currently seeking employment. Every form of data collection generates its own type of error. If you rely on government reports, error arises due to the unwillingness of some individuals to report events to government bureaus and to the failure of government bureaus to record some events (or to record them accurately). This problem has existed with both unemployment and crime indicators for some time. National crime surveys have identified many individuals who never report even serious crimes to their local police. Estimates of crime based on the FBI Crime Index always under-represent the level of crime present in any particular community and/or the nation. Certain kinds of crimes are systematically under-reported. Women under-report the occurrence of rape, and juveniles under-report the occurrence of physical assault. Not only is our image of the amount of crime too low, it is biased in that the frequency of property crimes is assumed to be higher than it is and the frequency of some of the violent crimes particularly among younger people is assumed to be lower than it is. Any careful measurement system must involve considerable efforts to obtain estimates of the error in the measurement system. All such efforts are expensive.

An alternative way of gathering data about unemployment and crime utilizes a random survey of households and/or respondents. While one is able to get a more accurate view of the extent of unemployment and crime through this mechanism, it is an expensive mode of data collection. It is itself a biased form of data collection. All data collection based on random samples of households or respondents are biased against families and persons who do not have permanent residences. Thus, large numbers of individuals who are unemployed and highly mobile would not be included in a normal random sample.

This has been a long answer, but one intended to illustrate the grave difficulties involved in getting accurate measures of such important public policy problems as crime and unemployment. There are many questions that social scientists can address using currently collected data. However, there are many questions for which current data is inadequate, and very expensive instrumentation and data techniques must be developed to obtain better measures.

2. "Are private sources of funding available for the social sciences?"

Yes, limited amounts of private funding exist for the social sciences as they do for the hard sciences. However, private foundations that support basic research related to medicine, chemistry, and horticultural development are more numerous than those that support research in other branches of the hard sciences and in most of the social sciences.

In your question you include one of the important rationales for government support for basic research. That is, that many of the results are general, and business and industry cannot afford the risks involved in supporting general results. A second major reason for governmental support of basic research in the social sciences is that many of the questions being sought are of such a broad societal nature that no single firm or foundation can adequately fund the appropriate level of inquiry. While a firm such as Kodak or Bell Telephone may support laboratories that undertake basic research related to the processes involved in their products, no industry can afford to undertake research related to broad societal questions such as the one I pursued above relating the amount of crime to the presence of unemployment in society.

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3. You refer to the Upjohn Institute at the Edna ~~McCullum~~ McConnell Clark Foundation a source of funding for the social sciences. You ask whether social scientists shy away from soliciting support from such institutions. Further, you ask whether greater prestige is attached to a National Science Foundation grant than a foundation grant. Let me answer the last question first. In some instances, greater prestige is attached to a National Science Foundation grant than to others because of the extremely rigorous peer review process used to evaluate grant proposals at the National Science Foundation. Thus, a scholar who receives an NSF grant has been reviewed by four to seven active scientists who are willing to attest that this scholar's work is at the forefront of his or her discipline.

As a social scientist who has visited many private foundations, I can attest to the much greater difficulty in obtaining funding from private foundations than from the National Science Foundation or the National Institute of Mental Health. Many private foundations are not interested in research at all. They are interested in action programs and do not fund basic or applied research. The grant application procedure used at foundations varies dramatically from that used at the National Science Foundation or the National Institute of Mental Health. Instead of a rigorous research proposal with documentation concerning methods, foundations want brief sketches in layman's language of the questions to be addressed. The judgment concerning funding is more likely to be related to the importance of the question to the foundation than to the capabilities, reputation, rigor, and skills of the researchers. Many social scientists engaged in basic research are hesitant to draft the "jazzier" types of research proposals called for by private foundations.

The Edna McConnell Clark Foundation does not accept proposals from individuals. Since many social scientists are not associated with research enterprises, they would be precluded from applying to this particular private foundation.

4. You inquired about the costs of conducting research in the legal mediation area. The problems of conducting any research on public policy areas result from the necessity of breaking out various types of problems and various types of interventions to ascertain how specific interventions relate to specific problems. Thus, simply to sketch out the problem: If there were 10 types of family problems that might be subject to mediation and 5 different mediation techniques, there would be 50 combinations of intervention techniques related to specific problems. For each of those 50 combined problem-type and intervention strategies, one would need to examine a fairly large number of instances to see what difference a particular intervention strategy makes in the outcomes over time. One would need, say 100 cases, for each of mediation problem-type combinations. That would add up to 50,000 cases to be examined. Data collection costs might range from $20 to $100 per case. Given this type of design matrix and these types of data collection costs, I think you can now see why careful evaluation of mediation techniques could be an expensive project.

Of course, if a project showed that some mediation techniques were very successful for some types of problems, the savings in court costs could be extraordinary and many times greater than the investment in the research.

This is not to say that small-scale, highly focused research projects could not be conducted on such questions. However, it would take a large number of such smaller scale projects to eventually provide an answer to the question of what type of mediation techniques appear to deal most effectively with family problems.

The CHAIRMAN. As soon as I return, we will call on Dr. Lattie Coor, president of the University of Vermont in Burlington, Vt., who will talk about physical sciences research.

With that, we will recess until I can get back from the floor from this rollcall vote.

Thank you.

[Recess taken.]

The CHAIRMAN. The hearing will be in order.

We are very happy to have Senator Robert Stafford with us here today. Senator Stafford is here to introduce Dr. Coor. Senator Stafford is an eminent member of this committee.

Senator, we appreciate your coming to introduce your colleague and the president of the college in your State.

STATEMENT OF HON. ROBERT T. STAFFORD, A U.S. SENATOR FROM THE STATE OF VERMONT

Senator STAFFORD. Thank you very much, Mr. Chairman.

I truly am pleased—and I do not say that in any pro forma sense—to have an opportunity to introduce to the committee Dr. Lattie Coor.

Lattie and I have been personal friends ever since he became president of our largest institution, the University of Vermont.

He has been president of that great university since 1976.

Lattie, my referring to it as a great university is quite a concession from a graduate of Middlebury College, as you may understand.

Dr. COOR. We deeply appreciate that.

Senator STAFFORD. Lattie Coor previously served as vice chancellor of Washington University in St. Louis, Mo.

Dr. Coor is testifying today before the committee on behalf of the American Council on Education and will speak to matters of critical importance not only to the University of Vermont, but to the Nation as a whole, in support of the Federal Government of basic scientific research through our colleges and universities.

Lattie is especially qualified to do this as he is currently serving as cochairman of the Joint Committee on Health Policy Matters of the National Association of Land-Grant Colleges and Universities and the Association of American Universities.

As always, I look forward to his testimony, which is always lively. I know that this committee will benefit from his views as we develop our initiatives for reauthorization of the National Science Foundation.

I am very pleased to present Lattie Coor.

The CHAIRMAN. Thank you so much, Senator Stafford.

Dr. Coor, we are happy to have you with us.

STATEMENT OF DR. LATTIE F. COOR, PRESIDENT OF THE UNIVERSITY OF VERMONT, BURLINGTON, VT.

Dr. COOR. Thank you very much, Senator Stafford and Senator Hatch.

There is more meaning than any in this room other than those of us from Vermont can appreciate in that warm applause he gives

the University of Vermont as a graduate of Middlebury, so that adds even more to my pleasure.

I am not quite sure I am as prepared as I should be to live up to the billing of a lively presentation, but I will do my best today, Mr. Chairman.

I did ask as I saw you leaving the rostrum for this last vote, since it was a different gait than I had seen when I last saw you, why the cane. I will simply note to you, as one who had the lack of wisdom yesterday afternoon to go skiing at Stowe with my 18-year-old who just came home from college, it is not as visible perhaps as a cane, but I have learned the folly of trying to keep up with the young man in my household, and I understand I may not be the only one who has learned that lesson.

The CHAIRMAN. I learned a very hard lesson, I will tell you. Playing basketball with a 12-year-old, I found out I am considerably older than I thought I was.

Dr. COOR. There are two reasons that I especially welcome the opportunity to appear before you today. I do so, as you will note from the formal record, on behalf of all of the major associations in this city related to universities: The Association of American Universities, the American Council on Education, the Association of Graduate Schools, the Council of Graduate Schools in the United States, and the National Association of State Universities and Land-Grant Colleges.

Not only do I represent them, but I would note what I believe are two very significant parts of this hearing and of this moment.

First, your committee, Senator, and you particularly, are among the few in this town that have the breadth of control and responsibility over a series of pieces that are integrated, not only the National Science Foundation, which is the purpose of our discussion here today, but the National Institutes of Health, the Department of Education. The counterparts on the House, where I have had the pleasure of appearing and where I have had a chance to talk with Members over time, are compartmentalized in a way that the whole is not able to be seen.

Those of us who live on campuses and see parts of the whole being integrated are often frustrated at our ability to fully express how all of these parts fit together.

The CHAIRMAN. You can imagine how frustrated we are on this committee since we have a more integrated jurisdiction but have to deal with the fragmentations in the House. Unfortunately, they have 435 people, all of whom want to participate in the process, so they have to fragmentize it over there.

A lot of people have not realized what a big authorizing committee this is. We have some 3,000 statutes we oversee, better than 260 entities of Government, and three Cabinet-level departments; you have summarized it very well.

I think it does help you that we on this committee can accomplish a lot of the things that need to be accomplished in a more comprehensive way, if we just sit down and do the job. We appreciate people, such as yourself, who help us to know what we should do, because we are all interested in trying to upgrade science and science education in this country.

Dr. COOR. I sympathize with your schedule and what it means for members of the staff. The ability to integrate is very important for us all.

The discussion of that artificial heart this morning—I was interested in talking with the representative here. They had involved the social sciences. There were major questions about the family and about the environment that were there. Issues of research on animals, for example, were an integral part of that. Each is a difficult question but all before this committee.

Second, I welcome the chance because I sense a new mood about the role of training of scientists and the support of scientists in their research in this room today and in this year, a very welcome change of mood, not only as reflected in your opening statement today, in the President's budget, but in the spirit of the remarks made by Dr. Branscomb and Dr. Knapp this morning.

It is, I believe, one of the most significant events of this current budget year that there is a new mood as it relates to the training of scientists and engineers and to an understanding that the stop-and-start funding of the last 20 or 30 years does not effectively accomplish a national purpose, and that the articulation of sustained base of support in the production of young scientists, in the nurturing of the work those scientists do, and in insuring that there is a tie between the various parts they represent, that that mood becomes the national policy of this country. That is really what I want to speak to briefly today and leave it to you and members of the committee to examine the formal statement that I have presented. If you wish to ask questions about it today, of course, or subsequently while the record is open—but to talk about the moment as we see it from the point of view of the universities and these associations, and very much encourage that this moment be seized.

I place this year's budget request in the context of the Nation's scientific capacity and of the articulation of a national policy with a small end but with a major role played by the Federal Government in articulating that policy.

In my judgment there is no question that we have fallen behind in the relative strength of our science and engineering in recent years. In the high-stakes, multinational game of the use of research and development to position whole industries, such as computers and microprocessing and biotechnology, our relative position has deteriorated. That is not an alarmist statement, but it is an observation of the relative position in which we find ourselves, ironically at the very moment that wide, visible attention to the fruits of science and technology are now being recognized in not only the President's visit recently to the Northeast to draw attention to the role of high technology, but public attention to the use of these new technologies, in the demonstration of the heart this morning, the role of computers in everyday life.

At the very moment the fruits of our efforts to date are being seen, there are signs of relative decline in competitive position, particularly in supporting the development of new scientists and new science work.

In the 1950's the United States was responsible for upward of 80 percent of all major technological innovations developed among the

United States, the United Kingdom, West Germany, France, and Japan. Just 20 years later, the comparable figure to that 80 percent was 50 percent.

Now, in part, it is because they have improved substantially, but our relative level of improvement did lose ground.

In 1965 U.S. scientists wrote 42 percent of the world's literature in physics. By 1977, just 12 years later, they accounted for only 30 percent. In engineering the decline over that same 12 years was from 50 to 40 percent.

There are ominous signs, in my view, that the level of national investment in science and engineering in the other countries, especially Japan, will put them in an increasingly strong competitive position in the future.

I do not think I have attended a meeting in the last year where the topic among academics, among industry representatives, among government leaders did not mention the production of engineers in Japan, in absolute numbers and relative to their whole population, as compared invidiously with the United States.

However, what is even more alarming to me—and I do not wish to state it in dramatic terms as much as to look at the long sweep of these matters, Mr. Chairman—is our current posture for the 1990's and the first decade of the 21st century, for the number of graduate students who are training and the quality of the research environment in which they are training right now will determine the quality of our science and of our relative position in terms of the advance of knowledge and competitively to these major industries now as a result of that. I believe there are signs that it is inadequate and that it has over the past several years undergone some slippage.

I believe, therefore, hoping not to overstate it, that we do have a major national problem and that there are ways together, in the partnership that has worked historically for many years, that we can provide support for basic research and to have the primary agent for the health of the academic sciences and the major force in supporting the training of young scientists and engineers—the Federal Government playing a cooperative role with all of us.

Why are we in the unenviable position that I mention? I would like to offer three reasons this morning, Mr. Chairman, and then turn to questions that you may have. I think each of these three questions bears on this budget before you today and on a series of related decisions that you and this committee and other Members of the Congress will make this year about the support of science and the training of scientists and engineers.

The first reason I think we are in the position we are today is because of the discontinuous nature of Federal support. Dr. Branscomb this morning talked about the post-Sputnik era. I was just entering a professional role in higher education at that period, in 1958, and I saw what happened to the National Defense Education Act and related efforts.

Just as with the first major government-university partnership that was dedicated to a national objective, the Second World War, it was a zero-to-full-throttle in 60 seconds—only, however, to peter out once the major perceived problems to which the National De-

fense Education Act, and before that the efforts around the Second World War, were designed, were solved.

There is an interesting contrast over the past 20 years to that approach with the approach that we followed with respect to biomedical research, where there has been a sustained, regular, fairly even, even expanding at times base of support, although I must note, though it is another topic, this year's budget proposals for NIH cause me some concern about that continuous support.

However, from it, we see the flow of trained personnel and research results that reflect the results of that policy. We are, and we remain, preeminent in the field of health and health science as a result of that.

However, over the same period of time funding for science and engineering has been cyclical and episodic. As I note in my prepared statement for you, the number of federally funded fellowships has declined precipitously from 51,000 in 1968 to fewer than 10,000 today, of which only about 1,500 are awarded to students pursuing advanced study in science and engineering, 500 of those in the NSF.

This discontinuous nature of support I think is one of the major problems that needs to be solved and why I find the spirit of restating a continuous policy over time so important.

Second, I would attribute to our current—our current problem I would attribute to the relative decline in the attractiveness of an academic career for scientists and engineers. There has always been a salary differential between industry and the universities. For those choosing an academic career, however, there have always been a number of compensating factors that made life in the university attractive.

First, the salary difference, while often large was not overwhelming.

Second, the academy offered an opportunity to pursue basic questions of the investigator's choice and to have some very able graduate students with whom to work.

Finally, the laboratory setting, a research environment in which the investigator worked was every bit as good, and occasionally better, than that in industry.

Each of these factors in an accelerated in the last 5 years has undergone a significant change. The salary differential appears to be changing especially for younger scientists and engineers. On my own campus, for example, a baccalaureate degree recipient in engineering starts at a salary higher than that paid his professor at the associate professor level. The $30,000 starting salary in industry for young computer scientists, when compared to 2 to 5 years of graduate study at a $7,000 stipend, is shifting the flow of young talent to industry and away from advanced study.

Similarly, the atmosphere for supported research and the opportunity to have an adequate number of talented graduate students is dwindling for our existing faculty. At the University of Vermont, for example, the number of applications for funding have remained relatively constant over the past 3 years. The actual amount of the awards supported is down by about 20 percent.

Finally, the state of laboratory equipment in research facilities is simply not competitive with industry and not adequate to the task.

At the University of Vermont we have improved our situation from an equipment replacement schedule, I am embarrassed to tell you, which 5 years ago was at a 100-year replacement cycle. We now have it at a 35-year replacement cycle, but that hardly meets the needs of contemporary science.

In 1970 it cost an average of $117,000 for a young scientist to establish a laboratory. By 1979 the counterpart figure was $741,000, and you will see in my statement a listing of the items of equipment necessary for a young investigator to get underway.

I believe, Mr. Chairman, that the President's budget, the NSF request, the basic thrust of this proposal this year represents a very significant beginning commitment to what I hope, and all of us at the associations I represent believe, can be a sustained and continuous commitment.

There are two items only I would add for special attention, and they, too, are spoken to in my statement. The value of the graduate fellowship at the level currently recommended is not going to solve our problem. I would commend to you and the committee staff the Office of Naval Research's plan where instead of roughly the figure that is contained in the NSF proposal—and let me get that precisely for you here—of $8,100, that the stipend be $12,000. Instead of the institutional allowance of $4,900, that it be $8,000.

My purpose in stating that is simply because of the competitive environment in which we are seeking to bring these young scientists into a position not to try to compensate them overly handsomely, but to be competitive.

Second—that, too, is in my prepared testimony—I would urge that you add one additional section to the very important work for graduate students, support for young faculty, and the commitment to the instrumentation that is in the bill. I would recommend strongly, and I do so on behalf of our associations, an additional provision for the renovation of research facilities. I recommend specifically that the amount be $75 million annually. That is based on the two attachments I have put in the statement today, work done by the Association of American Universities.

My reason for raising those two points is to try to fine tune and give you from the competitive environment in which I see this activity taking place a little fuller and more effective program, as embraced in the concept itself.

In conclusion, there is a third and final point why I think we are in the position we are today as a nation compared with the rest of the world and its science and engineering. We have an imperfect mechanism for integrating the efforts of the Federal Government, of industry, and of the universities.

Japan, for example, uses a cartel approach where there are very specific agreements about the partnership. Other countries do likewise.

I believe our approach is the wisest for us and that we should not try to emulate the approach taken elsewhere, but I believe there are ways jointly that we can improve our approach and make it a more perfect mechanism, wherein you, as the policysetters of the Federal Government, very importantly through this NSF budget, but through the other related budgets in the Department of Energy and in the Department of Education and Department of Defense,

make a basic policy commitment over time to what this Government believes should be the appropriate level of support for young scientists and engineers and for the basic work that is there.

We in industry, now that we are beginning to develop some rather impressive, new bilateral arrangements, arrangements that will not replace the Federal Government's role, particularly in training young scientists and supporting basic research, but that we perfect our part of the plan as well and that we take the tripartite arrangement which has worked well under crisis—the Second World War, the immediate post-sputnik era—and normalize it over the next 10 to 20 years.

With the direction set by this budget, I have a feeling of a confidence that we can make that partnership work more impressively than I think many of us a year or so ago thought would be possible in this decade.

It is for that reason that I come both with enthusiasm, with hope, and with the offer of whatever we can do from the staffs of our association at 1 Du Pont Circle, from our own campuses, to help augment the effort that is underway here and make that a commitment that really reaches beyond just this year.

[The prepared statement of Dr. Coor follows:]

STATEMENT

on the

FY 1984

AUTHORIZATION

for the

NATIONAL SCIENCE FOUNDATION

before the

Committee on Labor and Human Resources

U.S. Senate

by

Dr. Lattie Coor
President
University of Vermont

on behalf of

Association of American Universities
Association of Graduate Schools
American Council on Education
National Association of State Universities
and Land-Grant Colleges

March 18, 1983

Testimony before the Committee on Labor and Human Resources

Mr. Chairman and Members of the Committee:

My name is Lattie Coor and I am President of the University of Vermont. I am honored and pleased to have this opportunity to appear before you and to represent the research universities and colleges which comprise the membership of the Association of American Universities, the American Council on Education, the Association of Graduate Schools, the Council of Graduate Schools in the United States, and the National Association of State Universities and Land-Grant Colleges. As this Committee knows well, these associations together represent those universities and colleges that carry out the larger part of research and related education programs supported by the United States Government. Today I shall present to you our views regarding the FY 1984 budget request for the university research and related education programs of the National Science Foundation. In doing so, I shall first give our general reaction to the Foundation's requests and then place these in the context of the present condition and needs of the nation's research and graduate education enterprise.

GENERAL COMMENTS

I wish at the outset to emphasize that the FY 1984 budget request for the National Science Foundation is a strong step in the right direction. After a period of prolonged erosion in the research base of the nation, we are beginning to see, at least in selected areas, the kind of national commitment to excellence in basic science and graduate education that we believe to be absolutely essential to the long-term economic vitality, security, and well-being of our people. Governmentwide, much remains to be done to strengthen our investment in science and related educa-

tion programs, but here, in the FY 1984 budget request for NSF, we see an excellent first step. We particularly commend the Foundation for the strong commitments proposed this year for most basic research programs in the sciences and engineering. We note, however, the weakened position of the social and economic sciences, which remain budgeted below FY 1981 actual levels. The initiatives proposed to strengthen opportunities for young faculty, to renew the graduate fellowship programs, and to substantially increase the Foundation's investment in research instrumentation all deserve the support of the scientific community and, we hope, the support of the Congress. The merits of the proposed initiatives are best assessed in the context of the vitality of university research and education programs, of their unique contributions to the nation and to the national investment that is required in the programs carried out in the laboratories of our universities.

THE CONTEXT

A nation that seems to grow more complex and risky turns to our graduate schools for the continuing supply of talented individuals with the knowledge, technical skills, and perception on which depend our national security, our economic vitality, and cultural well-being. Without the well-educated men and women produced by our graduate and professional schools, we would be unable to sustain our economy, ensure our defense or hold our position of international leadership.

In a recent editorial in Science magazine, Philip H. Abelson wrote (and I quote):

> "We still lead in science, but our position is eroding. Unless a turnaround occurs soon in all levels of science education, we are headed for long-term inferiority."

I concur with this position, and assert further that if we as a nation fail to take specific targeted actions to improve graduate education and research training opportunities, we shall become a country of "less-developed scientists." Who will lead the world in creating and developing alternative energy sources, change the style of agriculture to slow soil erosion at home and around the globe, and exploit the opportunities of the revolution in the biology based on recombinant DNA? Without an infrastructure of strong graduate education, state-of-the-art instrumentation and scientific facilities, and the economic incentives for young scientists to pursue their careers in our universities and execute first-class research, we run the risk of depending on more-developed scientists in other nations of the world for our economic, social, and cultural well-being as we close out this century and move into the frontiers of the 22nd century. National funding and policy are essential for this infrastructure because I suspect that the sum total of decisions arising separately from the more than 300 Ph.D.-granting institutions will not provide a cohesive focus or make sense from a national standpoint.

Assuring a continuing infusion into our society of such talent is clearly a vital national interest. It stands as the major purpose and justification for the federal government's continuing attention to the health of graduate education and to the need for sustained investment in academic science.

A simple and clear prescription can serve as a guide to national policy with respect to graduate education. It is this: attend to the education and training of the nation's best minds or fall behind those nations that do.

But for a decade or more, as a nation we have departed from this prescription, and now the costs are beginning to be counted. Successive national administrations of both parties, confronted with real economic problems and the need to reduce federal expen-

ditures, have yielded too easily to the half-truth and the seductive notion that freely operating labor markets, unaided by external stimulus or correction, will produce the optimum number of highly trained, first-class people, distributed as needed throughout society.

Now, we see differently. There is ample evidence that the nation cannot presume the availability of a sufficient cadre of highly trained and talented scientists and scholars unless national policy provides incentives adequate to bring about that result. For fifteen years, federal support for graduate education has been reduced substantially. The national level of excellence in graduate education, especially in the context of sharply increasing international competition, has declined to the point that critical national needs served by graduate education are going unmet.

The quality of the environment for academic science and graduate education has suffered prolonged erosion. Today many of our leading graduate schools are seeing graduate enrollments tumble as undergraduate students clamor for the limited spaces available in our schools of engineering and computer science. The quality of instruction is being threatened. Faculty are strained to meet the demand, often without adequate assistance. More worrisome is the awareness that the ranks of truly talented young faculty coming along behind them are thinning. Time to pursue research frequently is squeezed, and the questions researchers are able to pursue in their investigations often are circumscribed by the obsolete instruments available to them. The capacity of faculty to substitute ingenuity for modern research tools is diminishing in many laboratories. In addition, many laboratories are aged; they require modernization if they are to serve through the decade as effective sites for the conduct of modern research. But, despite all of this, it is true that excellent research and quality education programs do continue in many laboratories. Many of those closest to the scene know,

however, that increasingly serious problems do plague our research enterprise, problems that left unaddressed will compromise our future.

Essentially all of our national policy objectives depend heavily on graduate education, both for highly trained personnel and for advances in scientific and technical knowledge that sustain our economy and ensure our defense. The present Administration has charted a course that requires significant real increases in total support for research and development, most notably in the area of national defense. The Department of Defense has proposed to increase its investment in university research programs, to initiate a small new program of graduate fellowships designed to attract a few of the most able undergraduates into graduate programs in fields linked to our national security needs, and it is undertaking a new 5-year, $150 million program to upgrade research instrumentation in laboratories that carry out research programs in areas related to our defense needs.

The FY 1984 budget request for the National Science Foundation provides significant real and most welcome increases in the Foundation's physical sciences and engineering programs. After almost a decade of neglect, steps to strengthen the NSF graduate fellowship programs also are proposed. Targeted attention also is being proposed to assist young researchers, who, with some encouragement at a crucial point in their careers, will pursue careers in academic science. But as welcome and important as these steps are, they are truly only the first steps we as a nation must take toward a more comprehensive, government-wide investment strategy for strength in the underpinnings for basic science and excellence in graduate education.

As we consider our future it always is good to reflect on the nation's history. It was the sudden dependence on university-based science and scientists during World War II that

led to a major emphasis on federal support for university programs of research and graduate training. The successful launching of Sputnik produced a new surge of federal interest in research and advanced education as components of a national effort to regain and sustain American scientific and technological superiority.

Beginning in the 1950s, by a variety of direct and indirect means, the federal commitment to excellence in higher education and research was developed. A tapestry of federal and private programs contributed to strengthening our research and graduate enterprise. At its peak, the commitment to graduate education included not only the National Science Foundation but the major mission agencies as well. The contributions by the Department of Defense and NASA to the health of graduate education are well known to the Congress and to this Committee in particular. The leadership provided by this Committee made many of these earlier investments possible. But although the federal government remains today a substantial patron for science, its investment in core programs designed to strengthen graduate education and contribute to the research and education environment in universities has diminished almost to the vanishing point in crucial areas. Four areas appropriate for consideration in the context of the FY 1984 NSF budget request are: graduate student support, the need to enhance career prospects for young faculty, research instrumentation, and research facilities needs.

GRADUATE EDUCATION

The existing matrix of federal programs providing graduate student support is the remnant of a clear recognition by the federal government in the past of the importance to the nation of strong graduate education programs. Many talented students have pursued advanced education in a wide range of academic specialties simply because federal assistance in many forms made it possible.

The modest yet perceptible increase in the availability of fellowships based upon merit and demonstrated academic excellence is an important step in the right direction. We must accelerate this program, for we have lost much ground evidenced by many recent developments. For example, for the first time in our history, 50% of the Ph.D's awarded in electrical engineering this year will be to persons who are not citizens of this country, most of whom have received financial support from their own government to pursue graduate studies. In addition, many young persons in this country with a new B.S. in computer science are demonstrating with their feet that they see more economic sense in taking that $30,000 job offer than opting for two to five years in graduate school with a fellowship stipend of $7,000 per year and perhaps accumulated debt of $8,000 to $10,000 over the period. In addition, proposed changes that would make graduate student participation in the Guaranteed Student Loan Program more onerous must be turned aside and compensated for by targeted fellowship programs based upon merit and the pursuit of excellence.

Federally funded fellowships were a clear success and an important, even determining, factor in the careers of numerous researchers who now are faculty in our leading institutions. The number of federally funded fellowships has declined precipitously, from 51,000 in 1968 to fewer than 10,000 today; of these only about 1,500 are awarded to students pursuing advanced study in the sciences and engineering; fewer than 500 of these are awarded annually by the NSF.

The new graduate fellowship program implemented this year by the Office of Naval Research offers a good model for the future development of the NSF fellowship program. It offers stipends of $12,000 and cost-of-education payments of $8,000 to institutions selected by students. These award levels recognize the demands of the marketplace of the 1980s and the present costs of graduate

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education in the sciences and engineering. An even stronger, more balanced approach would provide for a modest supplemental program, funded steady-state at perhaps half the program of individual awards, which would provide awards made to students through institutions that carry out NSF-funded basic research programs. Such balance between proven approaches is mutually reinforcing; and, for a relatively small incremental investment, it would have a substantial beneficial impact on the health of science and engineering departments that carry out energy-related research.

YOUNG FACULTY

Closely linked to the needs of graduate students are the increasingly serious challenges that face young researchers who seek to begin careers in basic science. As young Ph.D.'s complete their formal training those who aspire to academic careers face hurdles more serious than those their faculty mentors encountered. The attractiveness of an academic career is diminished and the prospects for a successful start need enhancing.

The 1982 AAU report to NSF, "The Scientific Instrumentation Needs of Research Universities," provides a striking example of the increased costs young researchers face as they seek to establish their research programs (see table on following page). The data now are somewhat dated, so the message they convey should be interpreted as a conservative estimate of present costs. In the case of a leading chemistry department the costs associated with equipping a new faculty member to do up-to-date research in the field of synthetic organic chemistry increased from $116,500 in 1970 to $741,000 in 1979. Inflation accounts only for part of the rising costs. Imposed on the rising baseline of inflation are much larger costs resulting from advances in existing instrumentation and the development of totally new, more powerful, and, therefore, more productive instruments. Young researchers of promise, who are yet without successful track records, cannot

TABLE 4. Increased Start-up Costs for Frontier Research (Synthetic Organic Chemistry)

1970 Instrument	Cost	1979 Instrument	Cost
		Laboratory Instrumentation	
Rinco evaporator - 2	$ 300	Rotavac evaporators	$ 1,700
2 vacuum pumps	400	Prep. liquid chromatograph with fraction collector	7,200
Distillation apparatus—spinning band	625	Analytical liquid chromatograph with recorder and data system shared with capillary column	13,250
Solvent stills - 3	600	Gas chromatograph	11,000
Melting point apparatus	150	Solvent stills with fire safety hoods	4,500
Gas chromatograph and recorder	1,450	Hot plates, stirrers, and heating mantles	600
Hot plates and stirrers, heating mantles	275	Microware with standard taper joints	3,000
Glassware	500	Laboratory glassware	800
Infracord Infrared Spectrometer	3,500	Thin layer chromatographic plates and tanks	1,500
TOTALS:	$ 8,000		$ 43,850
		Departmental Equipment to Which Access Required	
A-60 NMR Spectrometer	$40,000	90 mhz R-32 NMR spectrometer	$ 52,000
Cary 14 UV-Visible Spectrometer	14,000	200 mhz wide bore NMR spectrometer	225,000
Hitachi RMU-6 Mass Spectrometer	60,000	CFT-20 ^{13}C NMR spectrometer	60,000
Precision refractometer	2,500	GC-mass spectrometer and data system - Finnigan 4000	160,000
		Cary 17 - UV, Vis, Near IR spectrometer	32,000
		Digilab FT-IR spectrometer	82,000
		High resolution mass spectrometer - CEC - 21 - 110	110,000
TOTALS:	$116,500		$741,000

meet these costs without substantial assistance from their departments and institutions; and they are increasingly hampered in being able to respond.

Let me cite some facts about the University of Vermont that I believe characterize the conditions for our faculty at many of the comprehensive universities across the nation. The second major source of income at my institution arises from sponsored grants and contracts for research and training. Since FY 1980, the number of applications submitted by our faculty has remained fairly constant, as has the ratio of awards to applications. However, the amount of dollars awarded has been decreasing over the period and for the first half of the current Fiscal Year dollars awarded are down 20% against the corresponding period in FY 1982. Overall, our faculty secure funding for only 60% of the applications submitted, with this figure much lower for young faculty (I approximate about 40-50%), and are awarded a decreasing amount of funds particularly trying for the young investigator starting up his or her first laboratory. The young faculty at our institution are committed to the academy, are not discouraged and continue to seek external support for their research, but are very apprehensive about downward instability in federal and NSF funding and suggestions that private sector capital can replace government support for research and training. At my institution and those of our peers, 90% of the funding for research and training arises from the government, so we will continue to turn to agencies like the NSF even while we cultivate private sector support. I judge that 90% of the new scientists trained over the next 10 years must be supported by government funds, and the question before us is the quality and magnitude of this important component of the scientific infrastructure of this country which shall be supported by governmental funding.

The National Science Foundation proposes a new Presidential Young Investigators Awards program that will provide no more than 200 recent Ph.D.'s with 5-year awards averaging $30,000, to be

matched from private sources. The funds will enable these potential new researchers to undertake a research program promptly and to have a genuine opportunity to develop their skills as investigators in their early years. For some it will mean the difference between remaining in the academic environment and leaving to pursue more encouraging and fruitful alternatives. We vigorously support this important new initiative, and believe, if properly implemented, it will make an important contribution toward making the academic science laboratories more attractive career settings for talented young faculty.

RESEARCH INSTRUMENTATION

The third area requiring attention is the need to address the serious problems posed for modern research and quality graduate education by obsolete research tools. The instrumentation and equipment now being used in many of our research and training laboratories are seriously out of date. As previously reported to the Committee, a study completed in 1980 for the National Science Foundation found that the median age of instruments then in use in 15 universities surveyed was **twice** that of the commercial laboratories studied. That report, and others, have been provided to the Committee in earlier hearings; the Executive Summary is attached to my statement for the record.

The University of Vermont represents many of the moderately sized yet strong research universities--the comprehensive universities--and what follows for my institution is typical for many others in this category across our nation. In Fiscal Year 1978, the equipment replacement budget for the entire University of Vermont was $180,000 providing a basis for replacement every 100 years. Through our management efforts, we have improved the schedule so that we have a continuing base budget affording a 35-year replacement schedule ($506,000 in the base budget for FY 1983). Obviously, this situation is unacceptable for it means that in a given laboratory we might be training a

graduate student using an instrument that was purchased 15 years ago and our institutional budgeting would not allow replacement of that instrument for another 20 years. Please remember that I am speaking about just replacement and not acquisition of new and advanced instrumentation. We need federal support for the acquisition of state-of-the-art instrumentation, which has grown more sophisticated, costly, and involves multi-users so that instrumentation shortfalls are now no longer confined to one laboratory (as was the case 15 or 20 years ago) but impact a network of laboratories within a given university.

In three years, much has happened. Investment in research instrumentation by some federal agencies has increased significantly. The FY 1984 budget request for the National Science Foundation proposes a significant increase in support for equipment within its research programs. Among the mission agencies, the Department of Defense has recognized the consequences to its basic research effort of leaving the problem unaddressed. DOD this year is proposing the second year of a 5-year, $150 million program to upgrade research instrumentation in laboratories that carry out research programs of interest to the Department. This year the Department of Energy also has joined the effort with a new $6 million university research equipment program. That initiative is an important step for the Department.

An Interagency Task Force on University Research Instrumentation is continuing to explore the problem. Within the university community the AAU, joined by the National Association of State Universities and Land-Grant Colleges and the Council on Governmental Relations of the National Association of College and University Business Officers, hopes soon to undertake a special joint project to explore alternative approaches toward meeting the substantial backlog of obsolete equipment.

The significance of the research instrumentation investments proposed by the NSF is clear in comparison with those of DOD and DOE. The major commitment to modernizing research instrumentation being proposed by the Foundation places NSF in the lead position among all of the major agencies of the federal government. As important as the other steps mentioned above are to the overall effort, they do serve to emphasize the overriding importance of the Foundation's leadership and commitment to this area. We urge your full support for this very significant next step toward rebuilding our research capabilities.

RESEARCH FACILITIES

Turning to my final point, the need also to address the problems associated with deteriorated research laboratories, I find that the Department of Energy in its budget request states the general problem well, at least as it affects certain DOE facilities. In requesting $40 million for the Multiprogram General Purpose Facilities (MGPE), the Department in its budget justification states the following:

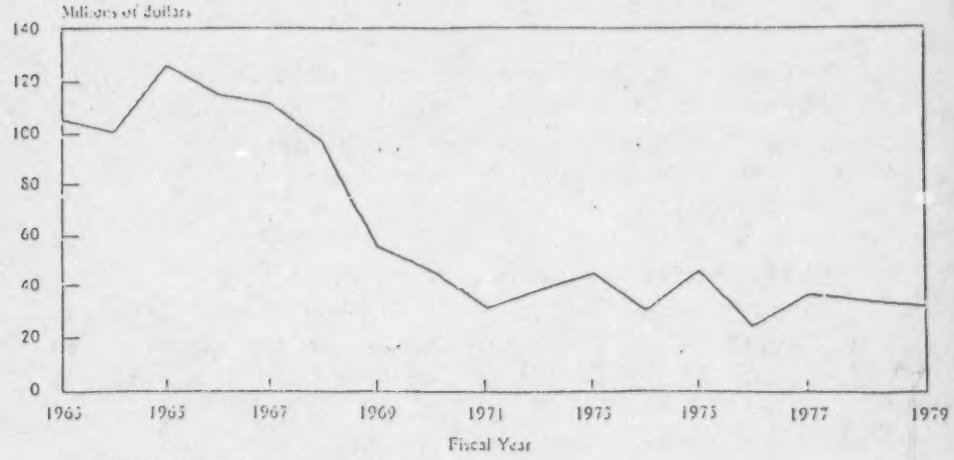
> "The program is based on the premise that through continuous usage and aging, facilities deteriorate over time to a point where they are no longer useful to perform their intended functions and must be rehabilitated or replaced."
>
> Source: FY 1984 DOE budget request, p. 121, 195.

In facing the serious problems of the DOE multiprogram laboratories, the Department is addressing the same problems spawned by obsolete facilities faced by many university researchers who seek to carry out NSF and other federally supported research programs in outdated laboratory buildings. The need to replace, renovate, rehabilitate, and reequip old research laboratories is the other half of the research equipment problem.

In many ways the equipment and facilities problems are intertwined. But, as a 1981 survey of research facility needs, also earlier provided to the Committee, points out, our leading research universities have substantial backlogs of research facilities in need of replacement, or at least modernization, if they are to be suitable sites for the conduct of state-of-the-art DOE-funded research programs. (The Executive Summary from that report also is attached to this statement.)

As shown by the following figure, for more than 15 years the federal government has invested essentially no funds to assist institutions in the replacement and repair of those laboratories in which the nation's basic science programs are conducted.

Figure 1. Federal obligations to universities and colleges for R&D plant



SOURCE: National Science Foundation

Many of these buildings were constructed 25 or more years ago in response to a national mandate; now many of those facilities need the same attention required by government-owned facilities--but for many financially pressed institutions the resources to do this job simply are not available. Since the alternative is the progressive deterioration of research laboratories essential to the nation's research base, and further deterioration in the quality of the science and education programs carried out in them, we believe it is time for the National Science Foundation, and the other leading agencies of the federal government that fund the nation's basic science programs, to assist in the rehabilitation of those laboratories essential to each agency's research mission and goals.

In the case of the National Science Foundation we ask the Committee to consider establishing a program to rehabilitate NSF-funded university laboratories at an initial level of $75 million.

CONCLUSION

We are hearing much these days, Mr. Chairman, about the potential to meet the nation's needs for research and highly trained people by forging closer ties between universities and industry. There are important opportunities, it is true, to strengthen those ties in ways that will result in greater investments by industry in university research and education programs. After looking at the current scene with some care, however, I can only conclude that the long-range potential here is probably considerably less that many would hope for. While much attention is being given to a relatively small number of potentially significant and highly publicized cooperative arrangements, it is good to remember that there is little here that genuinely is new. What is new is the intense interest focused on a few especially promising areas, particularly in the life sciences. For many other fields, little has changed. For most, sustained national

investment in basic science, funded through the agencies of our federal government, must continue to be the primary, even sole, source of research support.

The FY 1984 budget request of the National Science Foundation sustains and strengthens the nation's commitment to university research programs. We ask the Committee to fully support the Foundation's requests and to give serious consideration to building upon them along the lines suggested here.

I appreciate the opportunity to appear before the Committee today. I will be pleased to answer any questions you may have.

ATTACHMENT 1

THE SCIENTIFIC INSTRUMENTATION NEEDS OF RESEARCH UNIVERSITIES

THE SCIENTIFIC INSTRUMENTATION NEEDS OF RESEARCH UNIVERSITIES

A Report to the National Science Foundation

by the

Association of American Universities

June 1980

The Scientific Instrumentation Needs of Research Universities

EXECUTIVE SUMMARY

OBJECTIVES OF THE STUDY

- assess the current status of scientific instrumentation in major research universities
- identify factors which facilitate or impede its development, acquisition, use, and maintenance
- estimate the future consequences of present funding policies
- recommend appropriate policy changes

METHODOLOGY

- sixteen universities, six national and government laboratories, and nine commercial laboratories were visited; about 80 department heads and over 250 researchers and research administrators were interviewed in the universities; in addition, the views of approximately 60 researchers and research managers were gathered in visits to national, government, and commercial laboratories
- five fields of science and engineering were studied: physics, chemistry, biological sciences, earth sciences, and electrical engineering
- numerical data on instrumentation acquisition, age, and replacement were gathered from 14 universities and four commercial laboratories

THE PROBLEM

Instrumentation is essential for progress in experimental research. Scientific knowledge has advanced rapidly; new instruments, more costly but qualitatively superior to earlier ones, have allowed measurements previously impossible. The rate of change has been great, competition among researchers intense. The capacity of university researchers to work at the frontiers of knowledge has important consequences for the nation's future research productivity and for the training of future generations of scientists and engineers.

The federal government has adopted a variety of funding policies for the support of research instrumentation: the competitive project system, special instrumentation programs, formula grant programs, block-funded centers, federally sponsored research centers, and regional instrumentation centers chief among them. For about 15 years, federal support for basic research has gradually declined; now support levels are further strained by rapid inflation. But inflationary price increases are simply the rising baseline upon which are superimposed the frequently much larger increases resulting from instrumentation advances.

ASSESSMENT

The great diversity of instrumentation needs found among institutions visited precludes simple generalizations. However, problems in the acquisition, use, and maintenance of research instrumentation were found in all of the leading universities visited. The precise configuration of these needs and problems varies widely. The capabilities of institutions and departments to meet them do also.

University researchers face great difficulty in replacing worn-out or obsolete instrumentation and in acquiring new instruments needed for frontier research. A comparison of university instrumentation inventories with those of two leading commercial laboratories reveals that the median age of university equipment is *twice* that of the commercial laboratories' instrumentation. Even the nation's major research universities have not kept pace in meeting instrumentation needs. Researchers heavily dependent upon federal funds have witnessed grant size fall behind escalating research requirements. As a result, many work with inadequate tools that impair the pace

of research, force closure of lines of inquiry, strain operations and maintenance budgets, and compromise the advanced education of graduate students.

Start-up funds for new faculty often are shrinking as costs rise. Support equipment is needed to test, calibrate, and augment primary instruments. Often it is especially difficult to fund. Funding for operation and maintenance costs is increasingly difficult to obtain. As a result, faculty and students sacrifice research time to these routine tasks.

Many research facilities are in need of renovation or replacement; federal funding for these purposes has decreased, however, and universities lack the funds to respond. Signs that aging facilities now impede research were found in many laboratories and support facilities.

Local university needs vary widely, reflecting the unique circumstances under which each institution operates and the great diversity between and even within the five fields studied. Present funding policies do not provide sufficient flexibility to deal with such local circumstances.

When compared with government and commercial laboratories visited, most university laboratories fare poorly. The best-equipped industrial laboratories surpass almost all university laboratories visited. One university researcher captured the sense of disparity and observed, "the ivory towers are now in industry." The director of one leading industrial research laboratory described the struggle of university researchers as he has observed them as "pathetic." When asked to contrast their laboratories with foreign laboratories, a number of university researchers stated that many, most notably those in Japan and West Germany, are now superior.

CONCLUSION

The quality of research instrumentation in major university laboratories has seriously eroded. Not all, but many researchers in the nation's best-funded universities are struggling to work effectively with obsolete tools. The equipment being used in the top-ranked universities has a median age twice that of the instrumentation available to leading industrial research laboratories.

Three *causes* are identified:

- a relative decrease in instrumentation support
- inflexibility within the project system
- insufficient support for maintenance

Three major *consequences* are:

- diminished research productivity
- reduced training capacity
- decline in international competitive status

RECOMMENDATIONS

Federal policy for the support of research instrumentation should provide for a basic three-part funding strategy:

- strengthen instrumentation funding in the project system
- expand special instrumentation programs
- create in the National Science Foundation a new, supplemental formula grant program to provide needed flexibility to meet diverse institutional needs

FUTURE STUDIES

Five studies are recommended: 1) a thorough analysis of foreign research funding policies and programs and their implications for the competitive stature of American science should be undertaken; 2) a study of cooperative research arrangements between industries and universities and the factors—including federal policies—that encourage and discourage them is needed; 3) the planned assessment of regional instrumentation centers should include consideration of the concerns documented in this report; 4) universities should assess current instrumentation policies and develop mechanisms and incentives designed to promote effective sharing of instrumentation; 5) an assessment of the costs and benefits of federally-mandated equipment inventory and reporting systems should be undertaken.

ATTACHMENT 2

THE NATION'S DETERIORATING UNIVERSITY RESEARCH FACILITIES

A Survey of Recent Expenditures and Projected Needs in Fifteen Universities

July 1981

Association of American Universities
One Dupont Circle, N.W.
Washington, D.C. 20036

EXECUTIVE SUMMARY

OBJECTIVES OF THE SURVEY

This survey of 15 leading universities had three objectives:

-- In the institutions surveyed, document expenditures for research facilities and major ($100,000 or more) equipment, without regard to source of funds, over the last four years in the following six fields:

- Biological Sciences
- Chemical Sciences
- Earth Sciences
- Engineering
- Physics
- Medical Schools (10)

-- Provide responsible estimates, prepared by those universities, of expenditures for research facilities and major equipment that would be required over the next 3 years to meet the research and training needs of only current faculty.

-- From researchers and department heads, acquire assessments of the major consequences for science, industry, and government if the accumulating facilities needs of their institutions are not addressed.

FINDINGS

In many of the science and engineering departments surveyed, a substantial backlog of research facilities and equipment needs is accumulating. Projected funding needs over the next three years equal almost twice the level of expenditures by universities for their research laboratories and equipment over the past four years. Already, institutions often are unable to provide their basic science and engineering researchers and students with either the modern laboratories or equipment needed to conduct state-of-the-art research and education programs.

The loss of federal contributions to the support of research facilities and the absence of compensatory sources of support has forced many institutions to renovate and repair only those facilities in greatest need. Even this work often is carried out in a necessarily piecemeal fashion which is uneconomical over the long term. Working under such conditions, researchers unavoidably compromise their productivity and future competitiveness.

Relatively few construction projects have been completed in recent years in a majority of the physical sciences and engineering departments surveyed. Many institutions estimate substantial needs for new laboratories, for the expanded modernization and repair of old laboratories and for modern research equipment. Details are provided in the following report and the appendicies. The survey's principal findings are the following:

- In the last four years, for the six fields surveyed, fifteen leading universities together spent $400 million from all sources for facilities and major equipment. Half of those expenditures was for a relatively small number of new construction projects; the remaining half, spread over a larger number of generally less costly funding projects, was for facility modernization, major repair and renovation, and special purpose research equipment.

- In the next three years, the 15 universities estimate they should spend almost twice as much ($765 million) just to provide the necessary research facilities and special research equipment for current faculty only. These estimates are in current dollars and, therefore, do not include the added effects of inflation.

- New construction to replace outmoded facilities accounts for almost 60% of total projected funding requirements across all fields.

- In addition, substantial needs for major research equipment were identified in all six fields. These equipment estimates include only major items costing at least $100,000. As the 1980 AAU report to the National Science Foundation found, most departments also have serious deficiencies of less costly analytical instrumentation and support equipment.

RECOMMENDATIONS

The problems of obsolescence in the nation's university research facilities have been growing for more than a decade. To solve them, a new national investment strategy is needed. That strategy should provide direct, balanced support for university facilities from federal agencies and provide investment incentives designed to involve industry, the states, and the universities in a coordinated effort. The following steps are suggested as starting points:

1. Key Executive agencies should develop a mechanism to periodically assess the condition of university research laboratories and the consequences for the nation of that condition. Such assessments should involve the Office of

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Science and Technology Policy, the National Science Foundation, the Department of Defense, the Department of Energy, the Department of Health and Human Services, the Department of Agriculture and the National Aeronautics and Space Administration. The views of industry and the universities also should be solicited.

If the initial review corroborates the assessment of this suvey the following recommendations should be considered:

2. The facilities and equipment program earlier proposed to be undertaken by the National Science Foundation but deferred should be restored as a priority initiative in FY 1983.

3. The Department of Defense, Department of Energy, the National Aeronautics and Space Administration, the Department of Health and Human Services, and the Department of Agriculture should establish research instrumentation and facilities rehabilitation programs targeted on the fields of science and engineering of primary significance to their missions. The National Science Foundation should assist in the development, implementation, and coordination of those activities.

4. Incentives should be provided to encourage industries and the states to join with universities and the federal government in renewing the nation's university research laboratories.

5. Interest costs incurred in the construction, modernization, renovation, and repair of facilities in which federally supported research programs are carried out should be allowable indirect costs under OMB Circular A-21.

The CHAIRMAN. Thank you, Dr. Coor.

I have a number of questions I am going to submit to you in writing, but I have just one I would like to ask you today.

You have stated that 90 percent of the scientists and engineers in our Nation will be supported at one time or another by the Federal Government. That is certainly something to think about. Do you think that is a healthy trend to have 90 percent of the scientists and engineers in this country at one time or another supported by the Federal Government?

Dr. COOR. It depends on where and how that is done, Mr. Chairman.

As long as it is primarily a starter for the training that leads the scientist to be himself or herself fully trained and as long as it is related to the appropriate role of the Federal Government in basic research, the fact that each individual touches the Federal Government as part of their own evolution does not trouble me. I would be deeply troubled, and I sense your question suggests the same, if 90 percent of the scientific effort of this country were the responsibility of the Federal Government. That should not be.

Sharpening the division of labor so that the encouragement and support of people going into the sciences and the assistance at those critical moments for long-term support—the fact that it reaches such a large universe suggests to me perhaps the success of the program to date in this partnership that I described.

The CHAIRMAN. Thank you, Dr. Coor. We appreciate your being with us today. Thanks so much.

Dr. COOR. Thank you very much. It is a pleasure to be here.

[The responses to questions asked follow:]

The University of Vermont
BURLINGTON, VERMONT 05405-0160

June 21, 1983

The Hon. Orrin G. Hatch
Chairman
Committee on Labor and Human Resources
United States Senate
Washington, D.C. 20510

Dear Senator Hatch:

I very much regret the inordinately long time that I have taken in responding to a request that I received from you in mid-April, soliciting responses to several questions that you had intended to put to me following my testimony to your committee on the 1984 National Science Foundation authorization.

I have wanted to consult with other individuals knowledgeable on the issues you raised, and that has lengthened the time for response. I hope that the material enclosed will still be timely for the report of your committee.

I appreciated very much the opportunity to appear before your committee, and I look forward to meeting you again.

Sincerely,

Lattie F. Coor
President

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QUESTIONS FOR DR. COOR

- In your testimony, you state that we should not depend on the free market to provide the needed number of scientists and scholars. First, if not the market, who, then, determines the need? Second, to what do you attribute the alleged failure of the market to make these allocations?

- You note that only 1,500 graduate fellowships are awarded in the sciences by the federal government, and of these, only 500 are awarded by NSF. You are not including graduate level assistantships, fellowships, or post-doctoral positions which are included as part of the research grants. Am I correct?

- What other agencies support graduate students in science and engineering? What is the extent of their programs for this purpose? It is possible we should coordinate such efforts at graduate assistance to avoid duplication and unneeded administrative costs.

- On a different subject, I notice your emphasis on instrumentation. I don't believe there is a person in this room or a member of this Committee who does not share your concern regarding the state of American university laboratories. In fact, we continually express that concern and continue to authorize and appropriate funds for the procurement of new equipment and instruments. Haven't we made any progress at all?

- Can you tell us about a piece or two of equipment that NSF has helped the university community obtain? It is good that we know what we are buying?
- Several university administrators, I know of one at Colorado State and one at Harvard, have had some success with alternative financing of major instrumentation, Cyber computer systems, etc. Have you any experience with this type of project, and if so, is alternative financing a viable means of supplementing tight federal resources?
- Is there anything government can do to facilitate such alternative financing by universities and non-profit research institutions?

QUESTIONS TO PRESIDENT COOR FROM SENATOR HATCH--RESPONSES

1. Manpower in almost any field does not operate in a simple, informed, and open supply-and-demand marketplace. Your committee's experience with health personnel over the last dozen years provides an example of the complexity of the problem. First there was an identified shortage of physicians. Medical schools responded by increasing enrollments and graduation by 50% to 100%, and new medical schools were opened. Now there is a serious question concerning "overproduction." While this has been happening, there has been a continuing question over maldistribution, in terms of physician specialty and geographical distribution. How would we define the marketplace that would determine the number of physicians to be distributed where they were needed in various medical specialties?

Similar complexities prevail in the areas of scientists and scientific scholars. "Needs" generally are those identified by immediacy. The space program of the 1960's demanded very large numbers of engineers and space science specialists. Yet a decade ago there was an upsetting surplus of engineers and a loss of highly trained engineering specialists to crafts and businesses that enabled them to earn a living at that moment. Today, once again, we confront major shortfalls in the numbers of engineers needed in American business and industry, as well as in the specialized work relating to national defense. The marketplace would function if it were indeed an openly competitive market. But universities, constrained in their abilities to pay salaries above

certain levels, find themselves about 2000 professors short in engineering positions. Business and industry, operating quite easily by their rules, are creating a situation where there will be greater shortages of engineering graduates they will need because of the depletion of faculty. While we may turn to them and seek cooperative efforts with universities to try to resolve this situation, it might be going against the "nature of the beast" to demand major changes in the behavior of business. Needs for scientists, engineers, and related personnel will not be met if left to the contradictory and conflicting forces that exist in the complex marketplace operating today. Specialists in various disciplines working with industry and business to determine what personnel needs will be in the short and long haul and university officials responsible for the training of engineers and scientists and government officials who have available necessary data that will enlighten the situation, must work jointly to develop reasonable estimates of manpower needs that can be responded to by higher education institutions. I submit, Mr. Chairman, that, while it may be an error to produce more scientific specialists than might be needed a decade following their graduation, their capacity for adjusting their skills to other marked demands is quite high if their training has been proper. If we underproduce and find ourselves short of thousands of specialists a decade hence, it will take five to ten years of training to fill those gaps.

2. Your assumption is correct. The 1500 fellowships noted in our testimony is strictly defined as specific awards made by federal agencies to graduate students to enable them to complete their graduate

study. Probably from the beginning of modern graduate education, the most typical form of assistance to graduate students lay in research assistantships that enabled students and faculty to work closely together in a unique collegial relationship that many believe is one of the prized elements of American graduate education, particularly in the sciences.

3. In all likelihood, any agency that sponsors research and development activities in academic institutions simultaneously, if indirectly, supports graduate students in science and engineering through graduate research assistantships. At least three agencies, in addition to NSF, sponsored significant numbers of graduate fellowships in FY'83--the Office of Naval Research, the Department of Energy, and the National Aeronautics and Space Administration. Three others sponsor graduate traineeship grants to institutions that, in turn, make the actual individual award decisions--the National Institutes of Health, the Department of Education, and the Army Research Office. The staffs of these programs consult with each other formally and informally from time to time, and opportunities for coordination are regularly reviewed.

As a historic commentary on this issue--during the 1960's the federal government supported more than 50,000 predoctoral fellowships per year. While heavily concentrated in the National Defense Education Act Title IV program administered by the then Office of Education, and with major programs in the key science agencies such as NSF, NIH, about a dozen federal agencies participated in programs of meaningful size

including HUD, AEC, OCD, DOD, and, of course, NASA, NIH, ONR, and even the Smithsonian Institution had a small program oriented toward its special research concerns.

It is important to note that we have indeed made progress. Perhaps the most important step was taken by the Congress when it recognized the price of neglect over the past decade, and moved specifically toward easing and ultimately resolving the problem. Most specifically, a new program was opened this past year in the Department of Defense with $30 million set aside for instrumentation awards. Regrettably, these were not additional or new dollars but were taken out of existing funds, thereby removing $30 million from research grant awards. That program reflects both sides of the situation. The first is positive: A new program not available before that will provide desperately needed instruments in laboratories conducting research for DOD. At the same time the numbers in the program are most unsettling. 2500 proposals were submitted, far exceeding in funds requested the funds available. Obviously, the program could respond only minimumly to the very real needs. It is for this reason that you and your colleagues in the Senate House keep on hearing the same refrain despite the creation of new programs and dedication of dollars. As I noted in my testimony, a recent study concluded that university laboratory equipment was about twice the age of comparable instruments in industrial laboratories. These numbers have significant meaning in the capacity for conducting research. Our scientists are designing their research work around available equipment, avoiding doing what they should be doing because they lack the instruments to do the work

adequately. We believe that major new efforts must be made through all of the science agency budgets to update necessary instrumentation over the next several years and maintain state-of-the-art quality in laboratory instrumentation if we are to expect our university scientists to conduct research at the cutting edge of their disciplines.

4. Because it is the most recent program, the DOD distribution lists of awards made this past year for instruments might provide a sound answer to your question. It would reflect similar instrumentation purchase through NSF.

5. I am familiar with the work of Dr. Olson at Colorado State who has used creative approaches to financing major instrumentation with apparent success. Rep. Brown of Colorado has introduced a bill this year containing Dr. Olson's proposals for changes in the tax code that would permit many more institutions to undertake such alternative financing approaches. Serious attention is being given to the entire notion of alternative financing. At this time, the research intensive universities are seeking every means available to help resolve the shortages in equipment. It is my understanding that, for most universities, changes in the tax code would be imperative to provide them with the authority to undertake such financing activities. It is not entirely clear how the development of such new authorities would interface with existing authorities for issuing tax exempt bonds, an authority that is absolutely vital for institutions to secure funding for construction and in many cases student loans.

I have no specific recommendation at this time regarding the role of government in facilitating alternative finance purchase except to plead for a greater degree of imagination on the part of the Department of Treasury, where officials sometime seem incapable of distinguishing between universities, both private and public, and industries that may conduct various forms of research. The Tax Act of 1981, for example, did include provisions to encourage business and industry to make gifts both of instruments and funds to universities for the conduct of research. However, the legislation failed to provide a sufficient incentive that would have brought substantial funds into the universities. It is quite understandable that given current budget circumstances, both the Executive branch and the Legislative branch will seek to avoid as much as possible leakage from tax revenues. However, it may be imperative for the government to recognize the elements of investment inherent in university research activities and to forego some revenues in order to assure far greater revenues and other benefits many years later.

The CHAIRMAN. Our final panel will be on NSF's women and minorities programs. We will have two excellent witnesses: Dr. Shirley M. Malcom, director of the Office of Opportunities in Science, American Association for the Advancement of Science; and Dr. George Littleton, the associate dean for research, Graduate School of Arts and Sciences, Howard University, here in Washington, D.C.

We are very happy to have you be with us here today.

We are sorry that Dr. Elias Blake, president of Clark College in Atlanta, could not be here this morning.

We will turn first to you, Mr. Malcom.

STATEMENT OF DR. SHIRLEY M. MALCOM, DIRECTOR, OFFICE OF OPPORTUNITIES IN SCIENCE, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. MALCOM. Thank you very much for the opportunity to testify on the National Science Foundation's budget request for fiscal year 1984.

I am Shirley Mahaley Malcom, program head of the Office of Opportunities in Science of the American Association for the Advancement of Science.

For over a decade now the office has been involved in activities to increase the participation and promote the advancement of minorities, women, and persons with disabilities in science and engineering.

I would like to take this moment to recognize Senator Hatch's continued support for the handicapped in science efforts. We were very honored to have the committee cosponsor with us the Capitol Conference on Science and Technology for the Handicapped. We really appreciate your support for these efforts.

The CHAIRMAN. Thank you. That means a lot to me.

Dr. MALCOM. I have come to this committee today to address proposed programing and funding levels in the National Science Foundation budget for the minorities and women's portion.

I come as an individual concerned about the participation of women and minorities in science and engineering and in the activities of the National Science Foundation. I am not here to present the official views of AAAS.

I guess I must say that I have a selfish reason for being here, too, because I come as the mother of two little girls who recently announced their intention to follow their parents into science. I want to encourage them to pursue this goal, but I want to encourage them to pursue it with the idea that there are going to be opportunities for them to go as far as they possibly can and for them to achieve and reach whatever goals that they might set for themselves.

In that regard, I have 13 years to try to make a difference. [Laughter.]

I am very happy to see President Reagan's recognition of the pivotal role of basic research in our economic future. I am somewhat distressed, however, that there is not concurrent attention to the human resources that are available to science and engineering in this country.

In a budget which has seen increases or which calls for increases of almost 18 percent overall, the National Science Foundation proposes level funding of $2 million each for programs aimed at increasing research activity at minority institutions, the research improvement in minority institutions program, and for minority investigators at majority and minority institutions, the minority research initiation program.

Now, we all know that inflation eats away at the buying power of those dollars. Even in these days of only 4 percent inflation, level funding still means reduced funding.

In addition, the mix of programs aimed at minorities addresses only a very limited number of the barriers to participation in science and engineering. For Mexican-Americans, American Indians, and mainland Puerto Rican populations, groups which lack access to science and engineering degree-granting institutions which they control, program impacts can be limited at best.

The single program which is directed at encouraging research careers by women scientists and engineers, the visiting professorships for women program, has been slated for a one-third reduction in funding for the budget line item for the 1983 levels. We are talking about going from $1.5 million down to $1 million.

Now, according to the budget documentation which has been submitted by the National Science Foundation, the mandate of the individual research directors would be broadened to include support for this activity in an effort at mainstreaming these concerns for women. We are told that the half million dollars which has been removed will be more than made up for in the enhanced support for these women scientists by the research areas.

I spent 2½ years in the National Science Foundation as a program officer. I am, therefore, a realist about whether or not this can be accomplished in a manner that is going to really be satisfactory to those of us who care about the level of support and the attention to these problems.

The scheme that has been proposed presents untold management and accountability problems, including those related to tracking women applicants and grant recipients and distinguishing between women who are currently competitive in the NSF award-granting process and those that should be charged against the targeted goals for the visiting professorships for women programs, not to mention a real temptation which I must state: The difficulty of congressional oversight of a process that is so vulnerable to creative bookkeeping.

You have an excellent researcher. You get a little bit more money by charging her against the targeted funds rather than to use the funds which she has deserved, which she deserves in the sense that her proposal, her research, is meritorious, it is excellent, and it can stand up against any other piece of research that has been submitted or that has been proposed. That is a real temptation, and I think we have to recognize it as such.

I do not dismiss out of hand the desire to mainstream these programs. The ultimate goal is for all of these targeted programs to go out of existence, because we do not need them anymore, but that is not the case right now. We do need them. We need them for the leveraging value that they have.

I think it is possible to try this as an experiment without holding hostage the funds targeted for the visiting professorships for women programs.

In addition, the funding levels of the program, even at a $1.5 million level, signal the lack of a good faith effort on the part of the National Science Foundation to develop the research potential of women scientists and engineers. It totally ignores past proposal pressure for this program and minimizes the role and contributions of women as scientists and engineers in the national and international scientific and technological enterprise.

At this point we have a lot of concern within the scientific community, and I think that you do, too, here in the Congress, about what is happening in our graduate programs. A representative from the American Physical Society mentioned just 2 days ago that their graduate programs are approaching 40-percent enrollment in their doctorate programs by foreign nationals. We already know that this has happened in engineering, and yet we continue to squander the resources that are available within our own citizens, but from those segments of the population that we have not called on in the past to contribute to this national problem, and that is to the women of this country and to the minorities of this country.

When NSF is viewed in the light of its mandate to see to the health of science, one must question the level of funding within the budget, but one must also question the narrow range of programs that have been proposed to achieve this end of equal access to science by women and minorities. Even within a research framework, there are still a large number of programs which the NSF could offer on behalf of women, a counterpart to the minority research initiation program aimed at women scientists, for example, or an apprentice program for college women interested in graduate education to get early research experience.

The number of students supported on research projected funded by NSF far exceeds the number of portable fellowships at the Foundation. Yet, we do not even know how many women and minorities are being supported under these research grants.

At the present time there is something called the minority graduate fellowship program, which is proposed in fiscal year 1984 to support 45 minority fellows. Now this is only a little over 3 or 4 percent of all of these portable fellowships.

I think it was last year that not only black students received an award under the regular portable fellowship program within the National Science Foundation. So you can see the pivotal role of this targeted effort, because it does not look beyond merit; it looks to merit; it just looks at it differently.

It seems that there are many more opportunities to support the access and advancement of women and minorities in science and engineering than are currently being explored and pursed by the National Science Foundation in its programing. In 1980 the Congress of the United States passed, and the President signed into law, the Equal Opportunities in Science and Technology Act. The law spoke to the Nation's concern for the human resources that were available to science and engineering. I am sure that the framers of this law had in mind a much more comprehensive set of pro-

grams and activities than now remains in the National Science Foundation.

We are all aware that the support for these programs was cut back in 1981, along with all other new starts, in budget readjustments to achieve economic recover. Only modest support remained for several programs for minorities and women in the National Science Foundation. I must say that this committee was responsible in restoring some of those funds.

Those are the programs which are currently in place and for which continued level funding has been requested.

The President has recognized with his support this year for an unprecedented budget increase for the National Science Foundation, in spite of overall budget austerity and deficits, the pivotal role of basic research in our economic future. He has said, in essence, we can ill afford not to keep basic research strong. I say to you we can ill afford not to develop to its fullest the human talent available to do that research now or in the future.

Adequate support for basic and applied research is essential to the health of science in this country. The questions of the support needed to make women and minorities active participants in the research enterprise are also a part of what we are talking about when we discuss the health of science in this country. The Equal Opportunities in Science and Technology Act; the numerous bills that are under consideration in the Congress to address the crisis in science and mathematics eduation, (an issue that we have not even discussed here) the science education activities of the AAAS and of many of our more than 280 affiliates; the interest of the Governors of the different States and of the school boards and colleges and universities across this Nation tell us for once that we must reject the bandaid approach to fixing what is wrong with the current pool of scientists, engineers, and scientifically and technologically literate citizens. We cannot expect less from the agency charged with seeing to the health of science.

The CHAIRMAN. Thank you so much, Dr. Malcom. We appreciate your comments here today.

[The prepared statement of Dr. Shirley M. Malcom follows:]

TESTIMONY OF

SHIRLEY MAHALEY MALCOM
PROGRAM HEAD

OFFICE OF OPPORTUNITIES IN SCIENCE
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

BEFORE THE

COMMITTEE ON LABOR AND HUMAN RESOURCES
UNITED STATES SENATE

MARCH 18, 1983

25-953 O—83——9

Mr. Chairman and Members of the Committee:

Thank you for the opportunity to testify on the National Science Foundation (NSF) budget request for FY 1984. I am Shirley Mahaley Malcom, Program Head of the Office of Opportunities in Science of the American Association for the Advancement of Science (AAAS). For over a decade this office has undertaken activities to increase the participation and promote the advancement of minorities, women and persons with disabilities in science and engineering.

I have come to this Committee today to address proposed programming and funding levels in the NSF budget for our constituents - the population majority which is underrepresented in science and engineering. I come to you today as an individual concerned about the participation of women and minorities in science and engineering and in the activities of the NSF. I am not here to present the views of the AAAS.

Basic Research and Human Resources

The budget which the President has submitted for Congressional action calls for an almost 18% increase in funding for the NSF over FY 1983 levels. The increases are across all directorates, but particularly the most significant are those targeted for the mathematical and physical sciences and engineering (Intersociety Working Group, R&D in the FY 1984 Budget: A Preliminary Analysis, Washington, D.C.: AAAS, March 1983). These increases are consistent with the favored treatment seen throughout the budget for R&D for these fields over other fields of science.

Such favoritism has been based on the perceived tie between basic research in the hard sciences and engineering and the growth of high technology industries. This support has been seen as a long-term investment in our economic future and a way out of a difficult economic present. It is interesting therefore to note that the way out has been tied to research support without adequate attention to the human resources that will be available to science and engineering now and in the near and distant future. I speak of the programs to increase the participation of women and minorities in the scientific and engineering enterprise of this country.

Contributions to the Resource Pool

In 1981, 62,935 engineering degrees were awarded in the United States. According to the College Placement Council, engineers got 62.8% of all offers made to bachelor's graduates in 1982, but were only 6.3% of all graduates. The demand for engineers for that year far exceeded the supply of these highly skilled personnel. If we look more critically at the numbers, we find that these total degrees were made up of 56,390 men and 6,545 women (10.4%). In 1971 there had been only 353 women engineering bachelor's degree graduates or only around 0.8% of total. The increase in women engineering graduates during the late 1970's was an important part of our meeting national manpower needs in these critical fields. Think how much of a problem we'd have if women had not gone into these fields in record numbers.

In 1978 the National Center for Education Statistics (NCES) projected total engineering bachelor's degrees for 1981 at 68,210, with an estimated 6,210 degrees going to women and 62,000 going to men. NCES overestimated our overall output of engineers by about 8%, overestimated men's contributions to this figure by almost 10% and underestimated women's contribution to these numbers by over 5%. The example cited above is illustrative of the significant contribution of women to our national human resource needs in engineering and the sciences — a contribution often overlooked or at least underestimated.

It is important to note that these dramatic increases in the participation of women in engineering happened because of intervention and special efforts to make it happen — more and better career information, exposure to special support programs and role models, opportunities for research experience, etc. Many of the early intervention programs and much of the research which buttressed these special efforts were supported by the National Science Foundation, from programs which no longer exist, and for which little interest remains.

The Current NSF Plan

In a budget which has seen increases of almost 18% overall, the National Science Foundation proposes level funding of $2.0 million each for programs aimed at increasing research activity at minority institutions (Research Improvement in Minority Institutions)

and from minority investigators at majority and minority institutions (Minority Research Initiation). Level funding even in these days of 4% inflation means reduced funding.

In addition, the mix of programs aimed at minorities addresses only a very limited number of the barriers to participation in science and engineering. For Mexican-American, American Indian and mainland Puerto Rican populations, groups lacking access to science and engineering degree-granting institutions which they control, program impacts are limited at best.

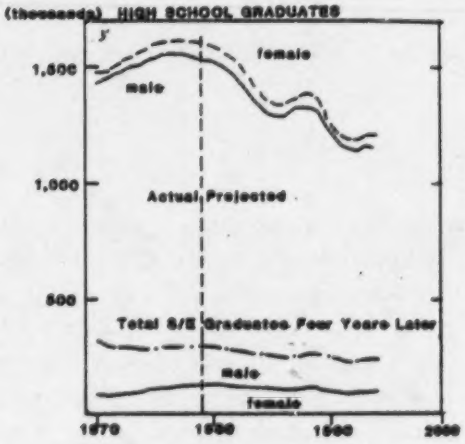
The single program aimed at encouraging research careers by women scientists (Visiting Professorships for Women program), has been slated for 1/3 reduction in funding for the budget line-item over 1983 levels — from $1.5 million to $1.0 million. According to budget documentation provided by the NSF, the mandate of the individual research directorates will be broadened to include support for this activity in an effort at mainstreaming these concerns for women, and the $0.5 million thus removed will be more than made up by the enhanced support of women scientists by the research areas.

Such a scheme presents untold management and accountability problems, including those related to tracking women applicants and grant recipients and distinguishing between women currently competitive in the NSF award granting process and those to be charged against the targeted goals for the Visiting Professorships for Women program — not to mention the difficulty of Congressional oversight of a process so vulnerable to "creative bookkeeping." I do not dismiss out of hand the desire to mainstream these programs but simply suggest that the mainstreaming effort might be tried as an experiment without holding hostage the funds targeted for the Visiting Professorships for Women program.

In addition, the funding level for the program signals the lack of a good faith effort on the part of NSF to develop the research potential of women scientists and engineers, ignores past proposal pressure for the program, and minimizes the role and contributions of women as scientists and engineers in the national and international scientific and technological enterprise.

A large part of the scientific and engineering community has come to the realization that most of the human resource potential and talent available to science and engineering in this country is being wasted. The demographic picture is clear, the

size of the college age population is decreasing and will continue its decline until the 1990's. Minorities are an increasing proportion of that 18 year-old population and together with non-minority females will comprise around 65% of the age cohort. We cannot ignore this proportion of a shrinking population age group. When we fail to develop the capabilities of minorities, women and disabled persons we squander this Nation's most valuable resource — its people.



Data Source: Supply and Demand for Scientists and Engineers, Scientific Manpower Commission (SMC), January, 1982.

Providing more support for research without corresponding attention to the human resources available to conduct that research, to develop products based on that research or to people the industries which must then produce and market those products is foolhardy. It is like the parable of the man who built his house upon sand rather than rock. When the flood waters came the house could not stand.

We are at a turning point today. Many have likened these times in our awareness of issues related to human resources available to science and engineering to the post-Sputnik period. Many in the Congress have become cognizant of the threat to our national security and our economic well-being posed by a scientifically and technologically illiterate populace.

What Needs To Be Done?

Why then do we not call upon the agency whose mission it is to see to the health of science in this Nation to live up to this responsibility. Bills have been offered to respond to the crisis in science and mathematics education but for the most part they have ignored the specific access problems of women and minorities. Much of the new found attention to science and mathematics education has been directed toward the Department of Education, ignoring the NSF's positive historical role and specific mandate to support basic research and science education at all levels. When NSF is viewed in light of its mandate to see to the health of science, one must seriously question this position. One must also question the level of funding within the NSF budget for programs to move minorities and women into science and engineering, as well as the narrow range of programs proposed to achieve this end.

Even within a research framework, there are still a large number of programs which the National Science Foundation could offer on behalf of women: a counterpart to the minority research initiation program aimed at women scientists; or an apprentice program for college women interested in graduate education to get early research experience. The number of students supported on research projects funded by NSF far exceeds the number of portable fellowships at the Foundation. Do we even know how many women and minorities are being supported under these research grants?

It seems that there are many more opportunities to support the access and advancement of women and minorities in science and engineering than are currently being explored and pursued by the National Science Foundation in its programming.

The Health of Science

In 1980 the Congress of the United States passed and the President signed into law, the Equal Opportunities in Science and Technology Act which is Title II of the NSF Authorization for FY 1981 (PL 96-516). This law speaks to the Nation's concern for the human resources available for science and engineering. I am sure that the framers of this law had in mind a much more comprehensive set of programs and activities than now remains in the NSF. We are all aware that the support for these programs was cut back in 1981, along with all other new starts, in budget readjustments to achieve economic recovery. Only modest support remained for several programs for minorities and women in NSF (those which are currently in place and for which continued level funding is requested).

The President has recognized with his support this year for an unprecedented budget increase for the National Science Foundation, in spite of overall budget austerity and deficits, the pivotal role of basic research in our economic future. He has said, in essence, we can ill afford not to keep basic research strong. I say to you, we can ill afford not to develop to its fullest the human talent available to do that research, now or in the future.

Adequate support for basic and applied research is essential to the health of science in this country. The questions of the support needed to make women and minorities active participants in the research enterprise are also part of what we are talking about when we discuss the health of science in this country. The Equal Opportunities in Science and Technology Act, the current bills now under consideration in the Congress to address the crisis in science and mathematics education, the science education activities of AAAS and many of our 285 affiliates, the interests of the governors of the different States and of school boards and colleges and universities across the Nation tell us that for once, we must reject the "band-aid" approach to fixing what is wrong with the current pool of scientists, engineers and scientifically and technologically literate citizens. We cannot expect less from the agency charged with seeing to the health of science.

We will now turn to Dr. Littleton, and then I will have some questions for both of you.

STATEMENT OF GEORGE K. LITTLETON, PH. D., ASSOCIATE DEAN FOR RESEARCH, GRADUATE SCHOOL OF ARTS AND SCIENCES, HOWARD UNIVERSITY, WASHINGTON, D.C.

Dr. LITTLETON. Thank you, Mr. Chairman and members of the committee.

I am Dr. George Littleton, the associate dean for research affairs, Graduate School of Arts and Sciences, Howard University in Washington, D.C.

I greatly appreciate this opportunity to present testimony on the matter of National Science Foundation and minority institutions.

Since its founding in 1867, Howard University has stood among the few institutions of higher learning where black Americans and other minorities can participate freely in a truly comprehensive university spirit. Thus, Howard has assumed a special responsibility to prepare its students to exercise leadership wherever their interests and commitments take them.

Howard has graduated more than 42,000 men and women in the professions—the sciences, the arts, and the humanities. The university has produced, and continues to produce, a high percentage of the Nation's black professionals in the fields of medicine, dentistry, pharmacy, engineering, nursing, architecture, law, religion, music, social work, teaching, and business.

The university consists of 17 fully accredited colleges and schools, with doctorates awarded in 23 fields, approximately 50 major graduate and professional programs, and over 75 major undergraduate programs. There are over 11,000 students from all across the Nation and more than 90 countries attending the university. The more than 1,900 faculty members represent the largest concentration of black scholars in any single institution of higher education. That is our qualification to address this issue.

The National Science Foundation has three programs specifically intended for minorities, two of which I am knowledgeable.

The minority graduate fellowships program, which Dr. Malcom has addressed, is intended to provide fellowships to minority individuals who have demonstrated ability and special aptitude for advanced training in science and engineering. Recipients must be working toward master's or doctoral degrees in engineering, mathematics, physical, biological, and social sciences, and in the history and philosophy of science.

The research improvement in minority institutions program—acronym is RIMIP—is intended to provide support for research needs at predominantly minority postsecondary educational institutions. These are institutions which have student enrollments which are more than 50 percent ethnic minority who have minimal participation in science and engineering. The program seeks to strengthen these institutions' research environments and thereby increase the contributions and participation of minority scientists and engineers.

Mr. Chairman, the objective of these programs is good. One program focuses on enhancing the minority scientific manpower pool

and the RIMI program seeks to increase the minority institution's ability to participate in Federal-sponsored research. However, I am very concerned that out of a budget of over $1.25 billion for the National Science Foundation, only $4 million, or less than 0.3 percent, is earmarked for these two programs.

In addition, of this small sum, the projected intent to level fund these programs for 1983 and 1984 is tantamount to program extinction in the face of inflation. Whereas, the 0.3 percent of the budget setaside for these programs is only a start toward impacting positively on these issues, it is very important. These funds have allowed the historically black institution a chance to enhance its ability to contribute to the scientific manpower pool. However, there is one additional problem that the minority institution now may face. This is called the classic trick bag. Many of these institutions may be trapped into applying for these small funds in the setaside program while being somewhat excluded from serious competition in the larger pool of scientific programs.

On September 15, 1981, President Reagan issued Executive Order 12320, with which we are all familiar, which addressed the historically black colleges and universities. I read from section 1 of that order:

> The Secretary of Education shall supervise annually the development of a Federal program designed to achieve a significant increase in the participation by historically black colleges and universities in Federal sponsored programs. This program shall seek to identify, re-reduce, and eliminate barriers which may have unfairly resulted in reduced participation in, and reduced benefits from, federally sponsored programs: This program will also seek to involve private sector institutions in strengthening historically black colleges.

Mr. Chairman, minority institutions will not be able to increase their participation in federally sponsored programs if the funds for the "minority" dollar, such as the set aside programs identified here, designed to enhance their ability to compete in the mainstream, are decreased.

The CHAIRMAN. Thank you, Dr. Littleton.

I appreciate the testimony both of you have given.

I might mention that we have another rollcall vote. Therefore, I have just a few minutes before I have to leave. Let me just ask a few questions and then I will submit more in writing.

Dr. Malcom, I am very interested in the fact that the National Center for Educational Statistics was so far off in its estimates of engineering personnel. Would you tell us to what you attribute this inaccuracy?

Dr. MALCOM. I do not think that the center really could predict what was going to happen to the college-age population, particularly the dropoff in young men actually going to college. There have been decreases.

That is the problem with putting all of your eggs in one basket. If you only depend on one segment to produce for you, when there are shifts in the behavior, then you get trapped. I think this is what happened to NCES. They thought that more young men were going to go on to college than actually did. They thought that more of them were going to opt for engineering than did. Therefore, in 1981, when it was a very critical time to have that engineering

manpower pool available, they were not there. In fact, women had to come in and make up the difference.

The CHAIRMAN. I see. I am impressed that you have mentioned really two specific program ideas here today: The apprentice research program for undergraduate college women and the research initiative program for women to expand on the visiting professorships for women. I think personally that these are ideas that deserve a lot of thought and followthrough. We will try to do that.

However, for now, I would like to just ask you this: How do you think the visiting professorship program is working? Has it been successful from your perspective?

Dr. MALCOM. I think that it has been successful. It has been successful on a number of measures. First of all, in terms of the attention that a number of women scientists are now paying to the National Science Foundation, seeing it as a place that is available and accessible to them, the merit—the high level of merit—in those proposals—if you remember, the Congress put in the half million dollars for that particular program. The number of meritorious proposals that could not be supported was so great that, in fact, the Director, then Dr. Slaughter, added almost another half million dollars so that the number of women that would be supported could be increased from the Director's reserve.

I think that that is testimony to the high quality of people that were attracted to that program. If there are that many that applied in the first year of operation of a program, think how many more deserving, qualified, talented people are out there.

As I indicated to you before, I have a real problem with the mix of programs. I have given some specific suggestions. I have a real problem with the level of funding to deal with an issue like this. We are talking about what, $5 million, to deal with the question of the talent that is available to science and engineering from women and minorities, to actually bring them into the mainstream of this activity. That is nothing. That is a trivial amount for the magnitude of the problem.

You should be looking at something that would be four times that amount if you really want to make some impact.

The CHAIRMAN. We ought to do that.

I thought Dr. Slaughter really tried to do a good job while he was NSF Director. I was personally very supportive of him.

Dr. Littleton, it seems to me that your statement supports Dr. Knapp's view that minority scientists are being inadvertently segregated into the specially earmarked programs for minority institutions and research. At least that is the way I derived it.

Dr. LITTLETON. Yes, sir.

The CHAIRMAN. Now if this is happening, I think we should correct that.

I might ask just this question: How do you suppose a proper balance could be achieved between these two courses, these two approaches, these two concerns?

Dr. LITTLETON. I think the significance of the RIMI program is that it addressed not necessarily developing institutions from ground zero, but it addressed enhancing a current research activity. The object here is to—maybe there is a laboratory at a minority institution that is working about 80 percent of maximum capabili-

ty. Given this source of funds, they now can compete in the state of the art across the board. These people then would not have to go for set-aside funds. They could go into the mainstream and compete in the mainstream.

I think the appropriate balance is that you do have to have set-aside programs to develop the capabilities to become competitive. That is what I was trying to say.

The CHAIRMAN. Thank you. I appreciate it.

As the coauthor of a number of the provisions with regard to women in science in the National Science Foundation, I really have appreciated this testimony. Let's hope we can do a better job in the future. I think it is a tribute to both of you that you have spent the time and the effort to be here and to testify before this committee.

It is an important bill. It is really important in the eyes of the American people, and it is important in the future of this country. I just hope that we can continue to augment the scientific, engineering, and other technological initiatives of the National Science Foundation. It is one of the organizations of government that really does try to do a tremendous job using merit as the criterion, and I think accomplishes an awful lot.

We have been happy to hold these hearings today. Let's hope that this reauthorization bill will fly through the Senate and the House with a great deal of speed and that we can take some of the suggestions that have been suggested here today.

Thank you so much.

[The following information was supplied for the record:]

NATIONAL SCIENCE FOUNDATION

SUMMARY OF FY 1984 BUDGET BY APPROPRIATION AND PROGRAM

	Actual FY 1982	*Request FY 1983*	*Current Plan FY 1983*	*Estimate FY 1984*	*Difference FY 1984/83*
Research and Related Activities Appropriation					
Mathematical and Physical Sciences	$272,842,614	$298,700,000	$299,716,437	$364,300,000	$64,583,563
Engineering	93,285,529	99,700,000	100,800,000	123,000,000	22,200,000
Biological, Behavioral and Social Sciences	176,597,165	186,700,000	190,242,890	223,600,000	33,357,110
Astronomical, Atmospheric, Earth and Ocean Sciences	259,852,856	273,700,000	276,109,368	334,900,000	58,790,632
U.S. Antarctic Program	88,504,786	86,400,000	83,200,000	102,100,000	18,900,000
Scientific, Technological and International Affairs	40,324,426	44,000,000	44,166,230	36,800,000	-7,366,230
Minority Institutions Science Improvement Program	—0—	3,287,000	—0—	—0—	—0—
Program Development and Management	63,182,341	63,081,000	65,312,404	66,000,000	687,596
Undistributed	—0—	—0—	4,500,000	—0—	-4,500,000
Subtotal, Obligations	974,589,717	1,055,568,000	1,064,047,329	1,250,700,000	186,652,671
Funding Reconciliation					
Unobligated Balances Brought Forward	-771,109	—0—	-2,347,329	—0—	2,347,329
Unobligated Balance Carried Forward	2,347,329	—0—	—0—	—0—	—0—
Adjustments to Prior Year Accounts	-5,030,809	—0—	—0—	—0—	—0—
Unobligated Balance Lapsing	459,872	—0—	—0—	—0—	—0—
Research and Related Activities Appropriation	971,595,000	1,055,568,000	1,061,700,000	1,250,700,000	189,000,000
Science and Engineering Education Activities Appropriation					
Graduate Research Fellowships	[14,999,999]	[15,000,000]	15,000,000	19,000,000	4,000,000
Pre-College Teacher Improvement in Science and Mathematics	—0—	—0—	15,000,000	20,000,000	5,000,000
Scientific Personnel Improvement	16,745,101	15,000,000	—0—	—0—	—0—
Science Education Development and Research	2,672,106	—0—	—0—	—0—	—0—
Science Education Communication	1,186,357	—0—	—0—	—0—	—0—
NSB Commission on Pre-College Education	293,672	—0—	—0—	—0—	—0—
Subtotal, Obligations	20,897,236	15,000,000	30,000,000	39,000,000	9,000,000
Funding Reconciliation					
Unobligated Balance Lapsing	2,764	—0—	—0—	—0—	—0—
Science and Engineering Education Activities Appropriation	20,900,000	15,000,000	30,000,000	39,000,000	9,000,000
Special Foreign Currency Appropriation					
Research and Related Activities	3,654,702	2,200,000	3,118,067	2,600,000	-518,067
Subtotal, Obligations	3,654,702	2,200,000	3,118,067	2,600,000	-518,067
Funding Reconciliation					
Unobligated Balance Brought Forward	-1,550,334	—0—	-918,067	—0—	918,067
Unobligated Balance Carried Forward	918,067	—0—	—0—	—0—	—0—
Adjustments to Prior Year Accounts	2,565	—0—	—0—	—0—	—0—
Unobligated Balance Lapsing	55,000	—0—	—0—	—0—	—0—
Special Foreign Currency Appropriation	3,080,000	2,200,000	2,200,000	2,600,000	400,000
TOTAL NSF APPROPRIATIONS	995,575,000	1,072,768,000	1,093,900,000	1,292,300,000	198,400,000

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NEW POLYURETHANE BLOOD VESSELS SOLVE BIG PROBLEM IN BY-PASS HEART SURGERY

A team of University of Utah polymer scientists has eliminated one of the troublesome problems of heart by-pass surgery by their pioneering work in developing polyurethane blood vessels.

The accomplishment caps 15 years of research during which the team solved the intricate problem of how to keep blood from clotting in extremely narrow synthetic polymer tubes--less than six millimeters in diameter, about the size of a thin pencil.

Dogs who have had artificial blood vessels implanted almost three years ago are doing well, paving the way for their use in humans, the researchers reported.

Dr. Donald J. Lyman, who heads the research group, said his team is in the process of obtaining Federal Food and Drug Administration approval to use the synthetic blood vessels in humans. He added that they already have several volunteers among

heart patients to be the first to receive artificial blood vessels.

While not as spectacular as the development of artificial hearts or other human organs, the blood vessel implants may be used more widely and more immediately, according to Dr. Lyman.

The Utah researcher told the National Science Foundation (NSF), which funded his research, that he expects artificial blood vessel implants to work better in humans since the clotting response to foreign materials is not as pronounced as in dogs.

The main stumbling block to the use of artificial blood vessels--clotting--was eliminated by extremely sophisticated basic research on the polymer material. This led to an understanding of the correct molecular structure needed to control the clotting reaction. The scientists found that even with this correct molecular structure, the synthetic blood vessel could fail if they did not match the elastic or rubber properties of the natural blood vessel.

The researchers were thus able to develop synthetic blood vessels that had both the correct surface structure and the matching elastic properties. In short, they developed tubes that are not only flexible but which pulsate--expanding as the blood flow increases and returning to normal when the flow decreases.

In conducting by-pass surgery today, heart surgeons commonly remove from the patient either of two large veins of the leg just beneath the skin's surface. They use this vein--called a saphena--to replace blood vessels near the patient's heart that either are blocked or damaged. Many patients who have undergone by-pass surgery complain that the removal of the vein from their leg bothers them more than the actual transplant.

In addition, many more patients simply don't have saphenous veins that are good enough for use in transplants.

"Some heart patients--10 to 25 percent--do not have satisfactory veins, either because of prior removal, disease or because the vein is of inadequate size for the intended replacement," Dr. Lyman said. "Even with the patients having satisfactory veins, one has to contend with the problem of limited quantity and, in many cases, a significant increase in operating time." A by-pass operation now may take as long as six hours.

These small-diameter artificial vessels will not only find much use in coronary artery repair, but they also can be used for peripheral vascular repair where now amputation of the leg is the primary "treatment", the researcher said.

Dr. Lyman said that an estimated 300,000 patients annually will benefit from the availability of these small-diameter artificial blood vessels. The Utah scientist, who is director of the university's Center for Polymer Implants, is optimistic about the future of the team's work.

"In 1978," he said, "the National Institute of General Medical Sciences entered the area with support which enabled us to expand the medical project part of our NSF research. We are continuing our research which led to this breakthrough in vascular prostheses by trying to improve vascular repair on very tiny vessels for hand, feet and brain surgery. This basic work is also assisting us in establishing needed knowledge for other implant applications."

The CHAIRMAN. With that, we will recess this committee until further notice.

Dr. MALCOM. Thank you.

Dr. LITTLETON. Thank you.

[Whereupon, at 12:15 p.m., the committee recessed, to reconvene at the call of the Chair.]

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